ANNUAL HISTORICAL REPORT
CALENDAR YEAR 1992

U S ARMY RESEARCH INSTITUTE OF ENVIRONMENTAL MEDICINE
Natick, Massachusetts

UNITED STATES ARMY
MEDICAL RESEARCH & DEVELOPMENT COMMAND

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This report contains information concerning the mission, organization, key staff, overall funding and significant research accomplishments of the US Army Research Institute of Environmental Medicine, a subordinate element of the US Army Medical Research and Development Command, for calendar year 1992. Also included are listings of published reports, abstracts, presentations and key briefings for each Research Division of the Institute and significant accomplishments and appointments of the professional staff.

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U.S. ARMY RESEARCH INSTITUTE OF ENVIRONMENTAL MEDICINE

NATICK, MA 01760-5007

CALENDAR YEAR 1992

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GENERAL INFORMATION

ORGANIZATION

The United States Army Research Institutc of Environmental Medicine (USARIEM) is organized with an Office of the Commander, the Military Detachment, three Research Directorates, a Research Programs and Operations Division and an Administrative Support Division. The organization chart of USARIEM is attached as Appendix A.

The three Research Directorates were organized on 1 October 1990 to consolidate eight Research Divisions, as follows:

a. The Environmental Pathophysiology Directorate, Dr. Roger W. Hubbard, Director. The Directorate incorporates the Cellular Physiology and Pathology Division and the Comparative Physiology Division.

b. The Environmental Physiology and Medicine Directorate, Dr. Kent B. Pandolf, Director. The Directorate incorporates the Altitude Physiology and Medicine Division, the Biophysics and Biomedical Modeling Division, and the Thermal Physiology and Medicine Division.

c. The Occupational Health and Performance Directorate, Dr. James A. Vogel, Director. The Directorate incorporates the Military Nutrition Division, the Military Performance and Neuroscience Division, the Occupational Medicine Division, and the Occupational Physiology Division.

The Research Programs and Operations Division, Dr. Murray P. Hamlet, Director, incorporates the Research Plans and Operations Branch, the Bioengineering Branch and the Animal Care Branch.

The Administrative Support Division, Marc L. Eisenmann, Major, MS, Chief, incorporates the Resource Management Branch, the Information Management Branch and the Logistics Branch.

LOCATION

USARIEM is located at the United States Army Natick Research, Development and Engineering Center (NRDEC), in Natick, Massachusetts.

ACTIVATION AND ASSIGNMENT

a. By Section VI, General Order 33, Headquarters, Department of the Army, 20 September 1961, USARIEM was established as Class II activity under the jurisdiction of The Surgeon General, effective 1 July 1961.

b. General Order No. 40, Department of the Army, Office of the Surgeon General, 1 December 1961, assigned USARIEM to the United States Army Medical Research and Development Command, Washington, DC, effective 1 July 1961.

c. The USARIEM was last provisionally reorganized by Memorandum dated 25 September 1990, signed by the Deputy Commander of HQ, United States Army Medical Research and Development Command, effective 1 October 1990.

TENANCY

a. USARIEM is a tenant on the NRDEC installation and receives administrative and logistical support from NRDEC on a reimbursable basis and in accordance with an annually renewed, intra-service support agreement.

b. The Pikes Peak Laboratory Facility, Colorado, is a subordinate activity of USARIEM and is utilized on a seasonal basis when a research requirement exists.

MISSION

To sustain and maximize the health and performance of individual military personnel, crews and troop populations through the conduct of basic and applied research programs in environmental medicine (heat, cold and altitude), and military work performance, training and nutrition. The Institute conducts basic research to elucidate mechanisms and sequelae of environmental stress and injury, and performs applied research to provide preventative and therapeutic countermeasures to the performance decrements, injuries and illnesses associated with military operations which expose forces to a wide spectrum of environmental conditions, physical and mental demands, materiel systems hazards and combat stress. Defines the complex interaction of environmental stress, operational stress and Army systems. Develops, evaluates and assists in the implementation of strategies to protect the soldier and enhance performance. In coordination with the U.S. Army Natick Research, Development and Engineering Center and through liaison with other Federal agencies, conducts research to develop the technology base required to evaluate feeding strategies for operational rations and nutritional supplements to minimize soldier performance decrements under sustained combat conditions. Discharges the Army Surgeon General's responsibilities as DoD executive agent for nutrition. Assists USANRDEC in the development of personal clothing and equipment by assessing the physiological impact of these items under all climatic conditions. Provides technical advice and consultant services to Army commanders, installations and activities in support of the Army Preventive Medicine Program and, on request, to other Federal agencies.

USARIEM
CY92

PERSONNEL

STRENGTH AS OF: 31 December 1992

CIVILIANS	AUTHORIZED	ACTUAL
SES	1	1
GM	9	9
GS	71	74
WG	0	2

OFFICERS	AUTHORIZED	ACTUAL
MC	6	8
MS	12	14
VC	2	2
SP	2	4

ENLISTED	AUTHORIZED	ACTUAL
	49	56

TOTAL:	AUTHORIZED	ACTUAL
	152	170

KEY STAFF AS OF: 31 DECEMBER 1992

Gerald P. Krueger, COL, MS, Ph.D., Commander and Scientific/Technical Director

Gaylord C. Lindsay, III, LTC, MS, Ph.D., Deputy Commander

Robert E. Burr, LTC, MC, M.D., Medical Advisor

Marc L. Eisenmann, MAJ, MS, Executive Officer and Director, Administrative Support Division

Monica L. O'Guinn, CPT, MS, Adjutant/Detachment Commander

Raymond W. Dickinson, SFC, Chief Medical NCO

James A. Vogel, Ph.D., Director, Occupational Health and Performance Directorate

John F. Patton, Ph.D., Chief, Occupational Physiology Division, Occupational Health and Performance Directorate

Bruce H. Jones, LTC, MC, M.D., Chief, Occupational Medicine Division, Occupational Health and Performance Directorate

Eldon W. Askew, COL, MS, Ph.D., Chief, Military Nutrition Division, Occupational Health and Performance Directorate

Mary Z. Mays, MAJ, MS, Ph.D., Chief, Military Performance & Neuroscience Division, Occupational Health and Performance Directorate

Kent B. Pandolf, Ph.D., Director, Environmental Physiology and Medicine Directorate

Michael N. Sawka, Ph.D., Chief, Thermal Physiology and Medicine Division, Environmental Physiology and Medicine Directorate

Richard R. Gonzalez, Ph.D., Chief, Biophysics and Biomedical Modeling Division, Environmental Physiology and Medicine Directorate

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Allen Cymerman, Ph.D., Chief, Altitude Physiology and Medicine Division, Environmental Physiology and Medicine Directorate

Roger W. Hubbard, Ph.D., Director, Environmental Pathophysiology Directorate

Wilbert D. Bowers, Ph.D., Chief, Cellular Physiology and Pathology Division, Environmental Pathophysiology Directorate

Ralph P. Francesconi, Ph.D., Chief, Comparative Physiology Division, Environmental Pathophysiology Directorate

Murray P. Hamlet, D.V.M., Director, Research Programs and Operations Division

Harold E. Modrow, III, MAJ, MS, Ph.D., Chief, Plans and Operations Branch, Research Programs and Operations Division

Andre A. Darrigrand, MAJ, VC, D.V.M., Chief, Animal Care Branch, Research Programs and Operations Division

John M. Foster, Chief, Bioengineering Branch, Research Programs and Operations Division

Richard L. Burse, Sc.D., Acquisition Management Liaison Officer, Plans and Operations Branch, Research Programs and Operations Division

Tim J. Jardine, CPT, MS, Chief, Logistic Branch, Administrative Support Division

Ms. Violet M. Trainer, Chief, Resource Management Branch, Administrative Support Division

Ghislain Busque, SFC, Chief, Information Management Branch, Administrative Support Division

Marie E. Stephens, Personnel and Manpower Section, Resource Management Branch, Administrative Support Division

ALLOCATION AND FUNDING

DA PROJECT NO.	TITLE	FUNDS
3M161101A91C	In-House Laboratory Independent Research	$ 50,000
3M161102BS15	Science Base of System Health Hazard Research	1,806,000
3M162787A875	Medical Chemical Defense - Exploratory Development	704,000
3M162787A878	Health Hazards of Military Materiel and Operations	530,000
3M162787A879	Medical Factors Enhancing Soldier Effectiveness	4,005,000
3M263002D819	Field Medical Protection and Human Performance Enhancement - Nonsystems Advanced Development	1,243,000
3M463807D837	Soldier System Protection - Advanced Development	143,000
3M464807D849	Infectious Diseases and Vaccine - Engineering Development	120,000
TOTAL FY92 PROGRAM		$8,601,000

USARIEM
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SUPPLY AND MAINTENANCE ACTIVITIES

During CY92, 5,459 requests were processed by the Logistics Branch as indicated below:

Expendable	3,326
Class VIII	537
MSO's	486
Non-Expendable	377
One-Time Service	339
Cylinder Turn-in	197
Continual Service	25
Work Orders	25
Durables	11
Precious Metal	9
Linen	7

The Biomedical Maintenance Branch performed a total of 4,625 Scheduled Service Actions and sent 251 items to Watertown, MA for calibration.

BUILDING AND FACILITY EQUIPMENT

- Completed office renovations for Rooms 137, 203, 216, 206, 144, 251, and 361.
- Acquired use of a 10 X 12 building (Building 10) for data storage.
- New environmental chambers 236A and 236C were accepted and installed.
- Contract awarded to make Environmental Chamber 024A operational.
- Request for proposals sent to prospective bidders on the replacement of Environmental Chambers 1, 2, 3, and 4.
- Interior hallways in the basement, first, second and third floors were painted.
- New chillers were installed in the altitude chambers.
- Initiated a design for the Biomechanics Laboratory for installation in Building 2.
- Building security system was installed.
- Immersion pool control and refrigeration replaced.
- Contract awarded to extend loading dock and install a logistics storage shed.
- Contract awarded to convert the incinerator room in Building 30 to office space for the Military Nutrition Division.

USARIEM
CY92

OFFICE OF THE COMMANDER

SIGNIFICANT PROFESSIONAL ACTIVITIES:

1. A 72-page U.S. Army Medical R&D Command handbook, "Sustaining Soldier Health and Performance in Somalia: Guidance for small unit leaders" was prepared for units deploying on Operation Restore Hope in Somalia. The handbook was prepared for U.S. Army Medical R&D Command under the general editorial supervision of the USARIEM Command Group, from input provided by the staffs of the Walter Reed Army Institute of Research and USARIEM. Of the 23,000 copies printed, more than 20,000 were distributed directly to deploying units and, for information purposes, to troop unit medical activities. Principal sections of the handbook were: Key preventive medicine measures; Climate of Somalia; Environmental risk factors; Infectious diseases; Plants, insects, snakes and other animals; Operational hazards; Nutrition and the Problem of Starvation, and appended work-rest and water consumption tables. The handbook is USARIEM Technical Note 93-1, DTIC ADA number 259302.

2. To complement the earlier environmental health and performance guidance for desert operations, USARIEM published similar guidance for cold-temperate and arctic operations, "Sustaining Health and Performance in the Cold: A pocket guide to environmental medicine aspects of cold-weather operations," USARIEM Technical Note 93-2, December 1992, ADA number 259920. This 71-page guide was prepared under the editorial supervision of USARIEM's Environmental Physiology and Medicine Directorate, with input from the Thermal Physiology and Medicine Division, the Military Performance and Neuroscience Division and the Military Nutrition Division. A companion handbook for unit medical officers on prevention and treatment of cold-weather injuries is programmed for early in CY93.

3. USARIEM undertook a major initiative in CY92 to expand its interaction with SOF, Ranger, Airborne and other units trained for rapid deployment. In addition to providing these units with relevant information from USARIEM's extensive knowledge base of environmental and occupational medicine, we are developing collaborative research relationships with these

units. The objectives are three-fold. 1) How can research knowledge presently on-hand be tailored to the needs of these units? 2) What methods need to be developed to enable the units to effectively apply current or new knowledge? 3) What are the needs for additional information not currently available that can be obtained through additional research? Thus far, collaboration with the US Army Ranger Training School has resulted in the completion of one study into the nutritional, strength and immunological impact of high levels of intense and prolonged physical activity under conditions of restricted calorie intake (Ranger I Study). The data collection phase of the follow-on study (Ranger II Study) was also completed during CY92. This study investigated the effects of enhancing the restricted Ranger training diet with selected military ration components to alleviate some of the deleterious physical effects found during the Ranger I study. A similar study is being planned for the initial SOF training phase at the JFK Special Warfare Center, as well as an investigation into the effects of enhancing blood red-cell content in SOF troops at high altitude.

4. The Surgeon General's professional short course "Current Concepts in Environmental Medicine" was delivered to 65 physicians and physician's assistants at USARIEM, 11-15 May 1992. Didactic units were presented in Effects of Heat, Cold and High Terrestrial Altitude; Epidemiology of Military Training Injuries; Physiological Effects of Back-packing Heavy Loads; Military Nutritional Needs, present and future; and Physical and Psychological Effects of Sustained Operations and Environmental Extremes. Because of recent emphasis on training injuries and physical requirements of the job, the Course is being re-designated, "Current Concepts in Environmental and Operational Medicine."

MANAGEMENT INITIATIVES:

At the request of the USARIEM Commander, a lengthy questionnaire survey of the Institute's employees was conducted by Mr. Raymond J. Zugel, Management Consultant to OPM. The focus of the survey was identification of potential improvements in organizational communications, management techniques and administrative methods, which will lead to increased work force productivity and job satisfaction.

Overall results of the survey were discussed with the entire work force. Specific results were discussed at length with the organizational managers in each Directorate, Division and Branch.

MILITARY PERSONNEL ACCOMPLISHMENTS:

At the U.S. Army Medical Research and Development Command "Soldier of the Year" competition for 1992, Staff Sergeant Linda S. Gowenlock, of the Altitude Physiology and Medicine Division, was first runner-up as USAMRDC NCO of the Year. In addition, eight soldiers completed Air Assault School, eight graduated NBC School (one as Distinguished Honor Graduate), three graduated ANCOC and six graduated PLDC.

PUBLICATIONS:

1. Babkoff, H. and G.P. Krueger. Use of stimulants to ameliorate the effects of sleep loss during sustained performance. Military Psychology, 4:191-205, 1992.

2. Krueger, G.P. Sustained work, fatigue, sleep loss and performance: Review of the issues. In: Proceedings of the International Conference on Human-Environment System (ICHES '91), Tokyo, Japan: The Organizing Committee for the International Conference on Human-Environment System, pp. 395-398, 1991.

3. Krueger, G.P. Environmental Medicine research to sustain health and performance during military deployment: Desert, arctic, high altitude stressors. In: Proceedings of the International Conference on Human-Environment System (ICHES '91), Tokyo, Japan: The Organizing Committee for the International Conference on Human-Environment System, pp. 583-586, 1991.

4. Krueger, G.P. Preface to the special issue: Stimulants to ameliorate sleep loss during sustained operations. Military Psychology, 4:189-190, 1992.

5. Lindsay, Gaylord C., III. Infectious Disease Rates in Operations Desert Shield/Storm, Army Research, Development and Acquisition Bulletin, pp. 28-29, May-June 1992.

6. Modrow, H.E., R.E. Burr, B.H. Jones, M.Z. Mays, P.B. Rock, M.N. Sawka, B. Petruccelli, W.T. Matthew, T.C. Murphy, N. King, S.R. Hursh, G.C. Lindsay and G.P. Krueger (eds). Sustaining soldier health and performance in Somalia: guidance for small unit leaders. U.S. Army Medical Research and Development Command. Published as USARIEM Technical Note 93-1, U.S. Army Research Institute of Environmental Medicine, Natick, MA, December 1992 (DTIC Accession: ADA259302).

SIGNIFICANT VISITORS:

1. Country: Australia
   Names: LTC I.D. Johnston
   Purpose: TTCP UTP-6 Meeting with Dr. Kent Pandolf

2. Country: Canada
   Names: Mr. Peter Tikuisis, Ms. Pearl Wu, Mr. Robert Boushel, Mr. Sidney Livingston, Mr. Thomas McLellan
   Purpose: To discuss mutual research interests with Dr. Kent Pandolf's Directorate, Environmental Physiology and Medicine, TTCP UTP-6 Meeting, Issues of Nutrient Data Base

3. Country: China
   Names: Dr Shuquin Luo
   Purpose To work as a research scientist with Military Performance and Neuroscience

4. Country: Germany
   Names: Mr. Ulrich Kraemer, Mr. Johann Kunz
   Purpose: To discuss mutual research interests with Dr. Murray Hamlet, discuss areas of Mutual interest with Dr. Richard Gonzalez

5. Country: Israel
   Names: Dr. Tadar Kadar, Dr. Aharon Levy, Dr. A. Shitzer, Dr. Itzhak Shalez, LTC Epstein Yoram, LTC J. Meyerovitch, Dr. Tashma Zeev, LTC Duer Ytzjak, Dr. Amitai Gabriel

Purpose: To discuss mutual research interests with MAJ Mary Mays, Dr. Kent Pandolf, Dr. Richard Gonzalez, and Colonel Gerald Krueger, respectively

6. Country: Korea
Names: Mr. Ki-Hoon Han, MG Chi Woo Lee, COL Na Hyean Jae, MAJ Chang Hoon
Purpose: Student Volunteer for Dr. Everett Harmon, Visit Institute and COL Krueger, respectively

7. Country: Lebanon
Names: Mr. Racheb Helayhel
Purpose: Student Contract for Dr. Allen Cymerman

8. Country: Netherlands
Names: LTC F. Bertina, MAJ E. Hendricks, Mr. M. VanDijk, Dr. R. Binkhorst, M. Hopman
Purpose: Exchange information and discuss present topics with LTC Robert Burr and Dr. Michael Sawka

9. Country: New Zealand
Names: Mr. Richard Parker
Purpose: Discuss mutual interests with Mr. William Santee

10. Country: Norway
Names: Per Kristian Opstad
Purpose: Collaborate on field feeding methods with COL Eldon Askew

11. Country: Russia
Names: Dr. Oleg Medvedev
Purpose: Present seminar and discuss areas of mutual interest with D. Harris Lieberman

12. Country: Spain
Names: Mr. Jose Alonso
Purpose: Discuss areas of mutual interests with CPT Scott Montain

13. Country: Switzerland
    Names: Dr. Traugott Zimmerli
    Purpose: Visit Institute and meet with Dr. Murray Hamlet to discuss mutual interests

14. Country: United Kingdom
    Names: Ms. Michael Stroud, Ms. Barbara Stone, Dr. Reginald Withey, Dr. Douglas Smith, COL John Sankey, COL Peter Lutter, Dr. Stephen Cole
    Purpose: First five names TTCP UTP-6 Meeting with Dr. Kent Pandolf. Others to discuss research projects with British Liaison and areas of mutual interests with Col Eldon W. Askew, COL Gerald P. Krueger and Dr. Richard R. Gonzalez.

COOPERATIVE RESEARCH WITH INTERNATIONAL ORGANIZATIONS:

"Hormonal and Cardio-renal Responses to Exercise at Extreme Hyperbaria". The Environmental Physiology and Medicine Directorate with CPT Beau Freund in a joint research project with Dr. Peter Bennet, Director, Hyperbaric Center, Duke University Medical School, Dr. John Claybaugh, Chief, Physiology Service, Tripler Army Medical Center and the countries of Germany, Sweden, France and England. This project is supported by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration. GKSS Forschungszentrum where the research was conducted is a German (government-supported) Institute.

FOREIGN SCIENTISTS WORKING AT USARIEM:

1. Dr. Avraham Shitzer, Department of Mechanical Engineering, Technion, Israel Institute of Technology, has been assigned as a National Research Council Senior Fellow to the Environmental Physiology and Medicine Directorate since September 1989. His assignment has been intermittent.

2. Dr. Shuquin Luo is a foreign scientist from China working with the Military Performance and Neuroscience Division as a National Research Council Fellow.

3. MAJ Barry Fairbrother, Royal Army Catering Corps, United Kingdom, has been attached to USARIEM from August, 1991, for

a two year assignment as a Special Projects Officer in the Military Nutrition Division.

MEMBERS ON INTERNATIONAL COMMITTEES:

1. COL Eldon W. Askew, is a U.S. delegate to Commonwealth Defense Science Organization (Food Studies Group).

2. Dr. James A. Vogel, is Chairman, NATO Panel 8, Research Study Group - 17, "Biomedical Aspects of Military Training"; and the Technical Cooperation Program (TTCP) Subgroup U, Action Group UAG - 12, "Physical Performance Enhancement of Elite Combat Units."

3. Dr. Kent B. Pandolf, is a member, International Society for Adaptive Medicine (Board of Trustees and Vice-President; The Technical Cooperation Program, Sub-Group U, Human Resources and Performance, Technical Panel 6 (UTP-6), Physiological and Psychological Aspects of Personal Protection (United States, United Kingdom, Canada, Australia and New Zealand) (U.S. National Leader); and Ergonomics Editorial Board Member (International Journal).

4. Dr. Richard R. Gonzalez is a member of the NATO Research Study Group 20/Panel 8, "Modeling in Cold Environment," planning the development of a working mathematical model on human responses to cold environments. Other countries involved are Denmark, The Netherlands, Canada, Belgium, Germany and Norway; International Standards Organization.

5. Dr. Andrew J. Young is U.S. Army Project Officer for Project Group 114, Aeromedical Considerations of Thermal Stress and Survival of the Air Standardization Coordinating Committee, Working Party 61, Aerospace Medical and Life Support Systems. Member nations are the United Kingdom, Canada, Australia and New Zealand.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Krueger, Gerald P., Ph.D., Commander. Immediate Past Chairman of the Department of Defense Human Factors Engineering Technical Group. Associate Editor, Military Psychology. Invited speaker: Joint Conference of the American

Psychological Association and the National Institute of Occupational Safety and Health; Meetings of Human Factors and Biomedical Devices, American Association for the Advancement of Science, International Conference on Human-Environment System, and Society for Technology in Anesthesia.

Lindsay, Gaylord C. III, Ph.D., Deputy Commander. Member, Combat Casualty Care Panel; Chairman, Subpanel for Treatment of Nuclear, Chemical and Biological Casualties; and Chairman, Subpanel for Far Forward Resuscitation for the Army Medical Department Concept-Based Requirement System; USAMRDC Representative, AMEDD Strategic Long Range Planning Conference.

ENVIRONMENTAL PATHOPHYSIOLOGY DIRECTORATE

RESEARCH FINDINGS: EXECUTIVE SUMMARY

1. USARIEM currently supports the only basic research and exploratory development program which utilizes several appropriate animal models, as well as cellular and organ models, to reproduce, diagnose, and treat experimentally the devastating sequelae of heat, cold or high altitude illness. Through an understanding of bodily defense mechanisms including systemic, organic, cellular and subcellular events, our overall goal is to elucidate predisposing factors and to prevent and treat serious or disabling injuries.

2. The program is directed at benefiting the soldier by improving survival from potentially fatal injuries (Preserve Life) and to limit or constrain morbidity under adverse environmental conditions with limited or acceptable decrements in performance (Remain-on-Duty). Whenever possible, civilian technological advances are exploited ("leveraged") to advance prevention or treatment of militarily relevant injuries.

3. The long-term research interests of our two Divisions include:

- Determining the pathophysiology of heatstroke from temperature regulatory collapse to multiple organ failure and shock.
- Elucidating metabolic, neuroendocrine, and immunoreactive bases for cardiac strain, vascular permeability and tissue edema.
- Applying monoclonal antibodies, agonists and antagonists to define and treat mechanisms of environmental injuries (heat, cold, and altitude).
- Defining molecular biology of environmentally-induced cellular adaptations.
- Investigating systemic and cellular effects of chemical agent/antidote pretreatment.

- Conducting structural-functional analyses of histological, cellular and ultrastructural changes due to environmental injury.
- Locating and identifying key receptor/enzyme sites and mechanisms of cellular injury and protection.
- Producing cellular models of inflammation, membrane permeability and ion pumping responses to thermal challenge and energy-deficient states.

PUBLICATIONS:

1. Hubbard, R.W., S.L. Gaffin, and J.R.S. Hales. Limits of tolerance to the heat. In: Handbook of Physiology: Adaptation to the environment. C.M. Blatteis and M.J. Fregly, (Eds.) Oxford University Press, New York, NY. (In Press), 1992.

KEY BRIEFINGS:

2. Hubbard, R.W. Overview of EPD Research Program for Dr. Per Kristian Opstad, Norwegian Defence Research Establishment. 11 February 1992.

3. Hubbard, R.W. Attended briefing on Chemical Defense Animal Program given by C.B. Matthew, Cellular Physiology and Pathology Division, to Israeli visitors, USARIEM, Natick, MA. 30 March 1992.

4. Hubbard, R.W. Review & Analysis for RA III Director and Staff and RA V Director and Staff. USARIEM, Natick, MA 2 April 1992.

5. Hubbard, R.W. Overview of EPD Research Program for James P. Bagian, M.D. and Astronaut, NASA, Johnson Space Center, Houston, TX. 20 May 1992.

6. Hubbard, R.W. Overview of EPD Research Program for Major General Chi Woo Lee, Commander, Armed Forces Medical Command, Republic of Korea. 21 July 1992.

7. Hubbard, R.W. Overview of EPD Research Program for Colonel Peter F. Lutter, British Medical Liaison Officer, Office of the Surgeon General. 1 September 1992.

SIGNIFICANT VISITORS:

Dr. Per Kristian Opstad, Norwegian Defence Research Establishment, Kjeller, Norway. 11 February 1992.

Michael A. Stroud, M.D. and Barbara M. Stone, BSc., Applied Physiology Division, Army Personnel Research Establishment (APRE), Ministry of Defence, Farnborough, United Kingdom. 20 February 1992.

Joseph Meyerovitch, M.D., NBC Branch Head, IDF Medical Corps and Lt. Col. Duer Ytzhak, Ph.D., NBC Protection Division, Ministry of Defence, Israel. 30 March 1992.

Stefan H. Constable, Ph.D., Research Physiologist, Sustained Operations Branch, and Dr. Leonard Luskus, Research Chemist, both from Department of the Air Force, Armstrong Laboratory (AFSC), Brooks Air Force Base, Texas. 7 April 1992.

COL Richard V. N. Ginn, USAMRDC Chief of Staff. 8 April 1992.

Professor Oleg S. Medvedev, M.D., Dean of Medical Faculty, Moscow State University, Russia. 14 July 1992

Dr. Donald Horstman, Environmental Protection Agency, Chapel Hill, North Carolina. 17 December 1992.

SIGNIFICANT TDY:

Roger W. Hubbard, Ph.D. Attended Prioritizing Pharmaceutical R&D Conference, Boston, MA, 15-16 June 1992. Attended 18th Army Science Conference, Orlando, FL, 21-25 June 1992. Attended Conference on Management of Biomedical Science and Technology, Frederick, MD, 16-21 November 1992.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Hubbard, Roger W., Ph.D., Research Director. Member, DOD Steering Committee on Field Water Quality. Adjunct Professor

of Pathology, Boston University School of Medicine, Boston, MA. Member, Editorial Board, Journal of Wilderness Medicine. Reviewer, Aviation Space and Environmental Medicine, Journal of Applied Physiology, and Journal of Wilderness Medicine. Invited by the American Physiological Society to co-author a chapter entitled "Limits of Tolerance to Heat" for the Handbook of Physiology. Invited by the Wilderness Medicine Society to write the 3rd Edition Chapter on Heat Illnesses for the text Management of Wilderness and Environmental Emergencies.

Dr. Hubbard's directorate was invited by Richard L. Miller, Ph.D., Chief, Crew Technology Division, Department of the Air Force, Armstrong Laboratory (AFMC), Brooks AFB, TX to work as consultants with Dr. Stefan H. Constable, AL/CFTO, on his protocol "Environmental Stress, Energy Balance Effects on Physical Fatigue."

COMPARATIVE PHYSIOLOGY DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

1. Research has been initiated on the cardiovascular, respiratory, microbiological, and thermoregulatory responses of miniswine to moderate hypothermia and rewarming. Specifically, the objectives of these experiments are: 1) to determine whether endotoxins have a plausible role in the pathophysiology of moderate hypothermia and rewarming; 2) to develop the minipig as an animal model for studying the potential role of endotoxins in the pathophysiology associated with hypothermia and rewarming. Using three chronically-instrumented miniswine ($\approx$ 30-35kg) we have perfected surgical techniques to implant mesenteric venous, hepatic venous and carotid arterial catheters, in addition to mesenteric arterial Doppler flow probes. Preliminary data suggest that cooling to and rewarming from a core temperature of 27°C results in a decrease in splanchnic blood flow with subsequent elevation of circulating endotoxin levels. The methodology for detection of gut-derived endotoxin release into the circulation is presently being refined. Appropriate anesthesia, cooling and

rewarming procedures are currently being determined. Preliminary data on clinical chemical indices, hemodynamic responses, and respiratory variables are being evaluated.

2. The effects of atropine on shivering and peripheral vasodilation in the cold, with attendant effects on thermoregulation, have been determined in a conscious, confined but unrestrained, hypotrichotic (Wistar-Furth, fuzzy) rat model. Electromyography (EMG) was utilized to assess the shivering response of the trapezius muscle. An EMG frequency band between 3 Hz and 1 kHz was rectified, then integrated for determination of a shivering index. Infrared thermography was used to monitor dorsal body skin temperature as an indirect assessment of cutaneous blood flow. Rats were injected in the lumbar musculature with either 1 mg/kg atropine (A) or an equivalent volume (0.15 ml) of saline (S) 30 minutes after exposure to one of three ambient temperatures (25°C, 18°C or 12°C). Data were then collected for an additional 90 minutes. There were no significant differences between group (A vs. S, $p>0.05$) in shivering, rectal temperature (T_{re}), skin temperature (T_{sk}) or tail temperature (T_{tail}) at 25°C (n=6/group), 18°C (n=7/group), or 12°C (n=12/group). However, modest within group decrements in T_{re}, (0.6°C and 0.8°C, $p<0.05$) occurred between 10 and 90 minutes following A injection at 18°C and 12°C, respectively. A transient decline in shivering occurred immediately following atropine administration at 12°C, but baseline levels were reached by 20 minutes post-injection. We conclude that intramuscular injection of A caused a small decrease in T_{re} in a cold-stressed hypotrichotic rat model. However, this decrease could not be entirely explained by shivering inhibition nor by cutaneous vasodilation, and may be due to a reduction in non-shivering thermogenesis.

3. Simultaneous implantation of flow probes and non-occlusive catheters to measure regional blood flow and arterial-venous differences of individual organs of the splanchnic bed was achieved in the conscious rabbit by designing, developing and modifying specialized probes and implementing unique micro-surgical techniques. To improve survivability, adult female New Zealand rabbits underwent a two-stage surgical procedure using a sterile technique. We used hypodermic needles and silastic adhesive to produce

Doppler probes of a known, fixed diameter to permit calculation of flow from KHz. Under isoflurane anesthesia a laparotomy was performed and the renal, mesenteric, iliac, or hepatic artery and portal vein were isolated and instrumented with a flow probe. Perfusion with 2% lidocaine reduced vasospasm permitting correct sizing of probes. A non-occlusive catheter, designed and constructed from medical grade silastic tubing and surgical velour, was then inserted into the respective vein. Instrumentation of the hepatic system was most complex because it required placement of probes on both the hepatic artery and portal vein, and non-occlusive catheters into both hepatic and portal veins. One week later, rabbits were re-anesthetized and non-occlusive catheters were inserted into the superior vena cava and abdominal aorta (level of the coeliac axis). All probe wires and catheters were routed subcutaneously, exteriorized, and secured within a plastic housing unit attached to the skin with surgical steel suture that also served as a grounding wire. Probes and catheters were evaluated daily. Chronic (30 day) patency and viability varied according to the vascular bed instrumented and animal access to wires: renal (n=9) 67%; mesenteric (n=14) 50%; iliac (n=5) 80%; hepatic (n=9) 33%. Pancreatic-induced inflammatory responses were identified via necropsy as the primary factor in non-recovery (first three days post-op). Generally, implants remained functional for three weeks, permitting chronic measurements of flow and blood variables to determine the delivery, extraction and consumption of substrates by individual organs in the conscious rabbit.

4. Arterial and venous blood gases and chemistries and organ blood flow were assessed in the splanchnic circulation of chronically-instrumented, adult, female New Zealand rabbits (n=23, 3.9$\pm$0.1kg) while resting and normothermic (T_{amb}=18°C). Blood flow was measured from Doppler probes implanted on the hepatic portal vein, and hepatic, superior and inferior mesenteric, renal, and iliac arteries. Blood samples were obtained from catheters inserted non-occlusively in the hepatic portal, hepatic, mesenteric, renal, and iliac veins, superior vena cava, and abdominal aorta (at level of coeliac axis). Measurements taken over 30 days showed stable cardiorespiratory variables by three days post-surgery. Mean ($\pm$SE) rectal temperature (39.6$\pm$.02°C), heart rate (223$\pm$4 bpm),

blood pressure (73$\pm$3 mmHg), PaO_2 (99$\pm$1 torr), $PaCO_2$ (35$\pm$.3 torr), pHa (7.40$\pm$.004), PvO_2 (52$\pm$1 torr), and $PvCO_2$ (38$\pm$.5 torr) were representative of a sedentary rabbit. Hemoglobin (10.6$\pm$.1 g/dl), hematocrit (31$\pm$.3 %RBC), osmolarity (339$\pm$3 mOsm), and total protein (5.0$\pm$.1 g/dl) were similar for arterial and mixed venous blood, and were comparable to published data for rabbits. Venous blood gases and chemistries differed among beds and from mixed venous blood; for example, hepatic vein PO_2 and mesenteric, iliac and portal vein pH were significantly lower while mesenteric and iliac vein PCO_2 were higher than mixed venous blood. Blood velocity to all organs was consistent with other species while calculated blood flow could not be precisely determined for all beds. O_2 extraction was not related to delivery and varied from 38% whole-body to 45-50% for the renal, mesenteric and iliac beds. While 60% of the O_2 delivered via the hepatic artery was extracted by the liver, only 10% was extracted from the portal vein. These results indicate marked differences in blood variables among tissue beds of the rabbit even under normothermic conditions, and that venous efflux from one organ is not representative of others in the splanchnic region.

5. Since the compensatory physiological adaptations which accompany exposure to heat stress do not provide protection from dehydration, it is important to assess the various fluid compartments of military personnel as they respond to varying degrees of dehydration. Therefore, the microswine was used as a model to measure fluid compartment shifts in response to dehydration as well as resuscitation regimens. Our findings to date indicate that exposure for 20-24 hrs to 31°C elicited 7% dehydration (body weight loss) which produced similar decrements ($p>.05$) in plasma volume (8.4%, 1.39 vs 1.28 L), extracellular fluid (8.0% ,10.97 vs 10.03 L) and total body water (7.8% ,22.10 vs 19.94 L). Calculated values for interstitial and intracellular fluid also indicated reductions (8% and 12%). These data demonstrate that 7% dehydration may elicit a redistribution of the body water compartments, especially intracellular water, to compensate for and protect against plasma volume loss. Further, the responses of the microswine are similar to those of humans and are apparently directed at minimizing plasma volume loss in order to preserve cardiovascular and thermoregulatory stability. As an adjunct to this investigation we are evaluating the efficacy of HSD

(hypertonic saline 7.5%, dextran) as an acute resuscitative regimen and its effects on already compromised fluid compartments.

6. An adenosine A1 antagonist [NPC 205](1,3-di-n-propyl-8-(4-hydroxyphenyl) xanthine) was studied to determine the effects of adenosine during exercise in the heat. We had previously reported that a 10 mg/kg dosage was apparently excessive, blocked both A1 and A2 receptors, and had no beneficial effects on thermoregulation or performance. Thus, in the current experiments we assessed the effects of a lower dosage on the ability of adult male rats (350 g, saline or NPC 205, 1 mg/kg,ip) to exercise (treadmill, 11 m/min, 6° incline) in a warm (30°C) environment. The endurance capacity of saline- and NPC-treated rats was not significantly different (41.4 vs 42.3 min). However, the NPC group exhausted at a lower core (41.4 vs 40.3 °C) and tail skin (34.4 vs 32.6 °C) temperature with elevated plasma lactate levels (6.4 vs 10.8 mmol/L) and accompanying acidosis (7.43 vs 7.34). Although the precise mechanism is unclear, it appears that any beneficial cardiovascular effects of this dosage of NPC was counterbalanced by an exaggerated metabolic response which contributed to exhaustion independent of thermoregulation.

7. In continuing our studies on the cellular and metabolic manifestations of heatstroke, the current study was designed to investigate the pathological sequelae of exercise and thermally-induced heatstroke. Using a primed constant infusion technique with radiolabeled ($^{3}H/^{14}C$)-glucose, effects on cellular energy (glucose) metabolism, ion fluxes, and nucleotide depletion are being investigated and related to the incidence and severity of heatstroke injury. To date animals were passively heated at 41.5°C until a critical core temperature of 42.5°C was reached. Preliminary data indicate that rats attained the critical core temperature after 262 minutes of exposure and lost an average of 36.5 grams body weight. Metabolic studies are currently being initiated.

8. Part of the difficulty in understanding the pathophysiology of heat stress/stroke is due to the small size of current laboratory animal models. Consequently, it has not been possible, <u>during a single experiment</u>, to obtain sufficient blood samples to conduct complete clinical chemical

analyses, while also measuring physiological variables such as cardiac output and blood flow in various regions. To address this problem, we have chosen as a new experimental model the Yucatan microswine, which is large enough to overcome the above difficulties (20-25kg), yet is of manageable size. In initial experiments control rectal temperatures were manipulated to 38°C$\pm$0.1°C by adjusting the ambient temperature. After a one-hour baseline period, ambient temperature was raised to 42.0$\pm$0.1°C (n=5), and, after a brief lag period, core temperature rose in a linear manner, to a final value of 45-46°C, at death. Control animals (n=3) remained at a mean T_{re} of approximately 38°C. Blood samples and physiological measures were taken at 20-minute intervals during the stabilization period, heat exposure, or equivalent control period.

Parameter	Results Obtained During Heat Stress
Mean Arterial Pressure	Stable until 42°C, then declined with a shoulder at 44.5-45°C.
Heart Rate	Rose to plateau at 39-43°C, rapidly increased to peak at 45-46°C, then plummeted to zero.
Hematocrit	Slow rise from 27% to 30% at 43.5°C then rapid rise to 47%
Hemoglobin	Stable at 9 g/dl until 43°C, then rapid rise to 15 g/dl
Total Protein	Stable at 6.3 g/dl until 44°C, then rose slightly to 6.8, at death
Sodium	Stable at 142 mmol/l but with a rising trend at 44°C
Potassium	Slow increase, then rapid rise from 4-4.5 to 6.5 mEq/l at 4 hrs

Calcium	Slow decline from 9.2 to 8.5 mEq/l at 44°C, then rapid rise to 9.5 at death
Magnesium	Stable at 2.5 mmol/l
Phosphate	Stable at 6 mmol/l until shortly before death, then rises to 8 mmol/l
PO_2	Stable at approx. 600 mm Hg until 44°C, then declines rapidly to 250 mmHg shortly before death.
PCO_2	Stable at 40-45 mmHg until 42°C, a small decline at 43°C and then large rapid rise to 210 mm Hg.
pH	Stable at 7.4-7.5 until 42°C, rises to 7.6 at 42.5-43°C, then declines to 6.9 at death.
Lactate	Stable at 12-15 mmol/l until 42.5-43°C, then rose to 20-30 at death

In summary, the experimental model provides sufficient blood volume for multiple sampling during a single experiment. We will now focus on clarifying the relationship between regional blood flow, and changes in blood chemistry to elucidate the sequence of events in heatstroke with an ultimate goal of improving therapy and prophylaxis.

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2. Armstrong, L.E., P.D. Szlyk, J.P. DeLuca, I.V. Sils, and R.W. Hubbard. Fluid-electrolyte losses in uniforms during prolonged exercise at 30°C. Aviation, Space, and Environmental Medicine, 63:351-355, 1992.

3. Armstrong, L.E., R.W. Hubbard, E.W. Askew, J.P. DeLuca, C. O'Brien, A. Pasqualicchio, and R.P. Francesconi. Responses to moderate and low sodium diet during exercise-heat acclimation. Proceedings of a Symposium, Committee on Military Nutrition, National Research Council, National Academy of Sciences Press, Washington, DC. (In Press), 1992.

4. Armstrong, L.E., R.W. Hubbard, E.W. Askew, J.P. DeLuca, C. O'Brien, A. Pasqualicchio, and R.P. Francesconi. Responses to moderate and low sodium diets during exercise-heat acclimation. International Journal of Sport Nutrition. (In Press), 1992.

5. Caretti, D.M., P.C. Szlyk, and I.V. Sils. Effects of exercise modality on patterns of ventilation and respiratory timing. Respiration Physiology, 90:201-211, 1992.

6. Durkot, M.J., R.P. Francesconi, and R.W. Hubbard. The relationship of plasma catecholamines to peripheral blood flow and thermoregulation during exercise in the heat. Journal of Thermal Biology, 17: 155-159, 1992.

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8. Francesconi, R.P., L.E. Armstrong, N. Leva, R. Moore, P. Szlyk, W. Matthew, W. Curtis, Jr., R. Hubbard, and E.W. Askew. Endocrinological responses to dietary salt restriction during heat acclimation. Proceedings of a Symposium, Committee on Military Nutrition, National Research Council, National Academy of Sciences Press, Washington, DC. (In Press), 1992.

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10. Gentile, B.J., C.R. Johnson, R.P. Francesconi, R.W. Hubbard. Thermoregulatory effects of atropine in the cold

using a hypotrichotic rat model. Proceedings of the Medical Defense Bioscience Review, Baltimore, MD. (In Press), 1992.

11. Szlyk, P.C., I.V. Sils, R.B. Mahnke, Jr., and R.P. Francesconi. Orthostatic tolerance after encapsulation in semi-permeable protective clothing. American Journal of Physiology: Regulatory, Integrative & Comparative Physiology, (Under revision), 1992.

12. Szlyk, P.D., D.M. Caretti, I.V. Sils, O. Zubal, and J.A. Faughn. Effect of Protective Clothing Ensembles on Artillery Battery Crew Performance. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report T8-92, 1992.

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14. Gentile, B.J., C. Johnson, R. Francesconi, R. Hubbard. Thermoregulatory effects of atropine in the cold using a hypotrichotic rat model. Medical Defense Bioscience Review, Baltimore, MD. Accepted for presentation.

PRESENTATIONS:

15. Gaffin, S.L. Anti-LPS and shock. Tufts Veterinary School, Grafton, MA, 25 March 1992.

16. Gaffin, S.L. Endotoxemia during marathon runs. American Medical Athletic Association, Boston Marathon, 19 April 1992.

17. Gaffin, S.L. Endotoxins in several kinds of stress. Oklahoma Medical Research Foundation, Oklahoma City, OK, 18-20 November 1992.

18. Gaffin, S.L. Lipopolysaccharides from stress. Department of Microbiology, Boston University Medical School, 15 December 1992.

KEY BRIEFINGS:

19. Francesconi, R.P. EPC Research Program, Colonel Peter F. Lutter, British Medical Liaison Off'cer, Office of the Surgeon General. USARIEM, Natick, MA. 1 ptember 1992.

20. Francesconi, R.P. EPC Research Program, Colonel R. Ginn, CS, USAMRDC. USARIEM, Natick, MA. 8 April 1992.

21. Gaffin, S.L. EPC Research Program, Major General Chi Woo Lee, Commander, Armed Forces Medical Command, Republic of Korea. USARIEM, Natick, MA. 21 July 1992.

SIGNIFICANT VISITORS:

Prof. Paul Black, Head, Department of Microbiology, Boston University Medical School. 20 May 1992.

COL Richard H. Seder, M.D. (IMA to USARIEM), Acting Chief, Department of Laboratory Medicine, and Medical Director, Transfusion Medicine, University Hospital, Boston, MA. 31 August-11 September 1992.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Francesconi, Ralph P., Ph.D., Division Chief. Proposal reviewer, Army Research Office. Advisor, NAS/NRC Research Associateship Program. Reviewer, Aviation Space & Environmental Medicine, American Journal of Physiology, Physiology and Behavior, Kidney International, and Journal of Applied Physiology. Invited by the American Physiological Society to author chapter entitled, "Endocrinological and Metabolic Response to Acute and Chronic Heat Exposure" for the Handbook of Physiology.

Durkot, Michael J., Ph.D., Research Physiologist. President, Natick Chapter of Sigma Xi, the Scientific Research Society (Jul 91-Jun 92). Reviewer, Aviation, Space & Environmental Medicine, Circulatory Shock, and Journal of Applied Physiology.

Gaffin, Steven L., Ph.D., Research Physiologist. Reviewer, Perspectives in Exercise Science and Sports Medicine, Volume

6. Invited by the American Physiological Society to co-author a chapter entitled "Limits of Tolerance to Heat" for the Handbook of Physiology. Official Reviewer, Conference on Perspectives in Exercise, Science, and Sports Medicine/Exercise, Heat, and Thermoregulation in Baveno, Italy.

Szlyk, Patricia C., Ph.D., Research Physiologist. Special Awards Judge, U.S. Army Laboratory Command, International Science & Engineering Fair. National Finalist, Reserve Officer Association Junior Officer of the Year. State of Massachusetts, Reserve Officer Association Junior Officer of the Year. Member, Executive Committee, Natick Chapter of Sigma Xi, (Jul 91-Jun 92). Reviewer, Aviation, Space & Environmental Medicine and Journal of Applied Physiology.

CELLULAR PHYSIOLOGY & PATHOLOGY DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

1. Endothelial cells (ECs) line all blood vessels and function as a barrier that influences blood vessel permeability and thereby the volume of fluid in the vascular space. Exposure to hyperthermic conditions can adversely affect vascular volume to reduce soldier performance. To evaluate the direct effects of heat on EC permeability, bovine aortic endothelial cells (BAECs) were seeded on permeable membranes. After seven days, the cultures were exposed to 37°C, 41°C or 43°C for 30 or 60 min. Following exposure, cultures were fixed with 3.7% formalin. Intercellular permeability of the fixed cultures was determined by following the passage of dextran fluorescein (7.0×10^4 MW; 20 µM) through the BAEC-covered membrane. F-actin, a protein constituent of the EC cytoskeleton, plays a pivotal role in barrier function, since it provides the tensile forces that sustain junctional integrity between cells. BAEC F-actin level was quantitated by measurement of rhodamine phalloidin binding capacity. Similar permeability with significantly elevated F-actin levels were noted for 41°C, when compared to 37°C-exposed BAECs. Significantly increased F-actin levels were also noted

for cultures subjected to 43°C. However, permeability was significantly greater relative to 37°C controls. BAECs responded to the hyperthermic challenge with an elevation in F-actin level. This response sustained barrier function at 41°C, but was no longer effective at the hyperthermic extremes of 43°C. These findings have identified the effects of hyperthermic exposure on EC barrier function, which can serve as a bases for the design of interventions to support vascular volume in soldiers subjected to hot environments.

2. Atropine (AT) induces a dose-dependent increase in rate of rise of core temperature in the sedentary heat-stressed rat. Anticholinesterases such as the pretreatment drug pyridostigmine (PY) offset the effects of anticholinergics such as AT. Prior to determining if there is an alteration of AT's anticholinergic potency following acute or subchronic (2 week) PY administration, we determined doses of PY that would elicit the 40% inhibition of cholinesterase (ChE) seen in soldiers taking the recommended prophylactic dose of 30 mg three times a day. A 100 ug/kg dose of acute PY iv in 0.2 ml saline elicited approximately the target 40% (44 $\pm$ 2%, mean $\pm$ SE) ChE inhibition 60 min after injection. Subchronic administration of 20 ug/hr of PY or saline via osmotic pump resulted in 47 $\pm$ 5% inhibition after 7 days and 48 $\pm$ 4% after 14 days as compared to animals given saline via osmotic pump whose inhibition levels were -3 $\pm$ 9% after 7 days and 3 $\pm$ 8% after 14 days. Sedentary heat-stressed rats given these doses of acute and subchronic PY will be used to determine if there is an alteration of AT's anticholinergic potency following acute or subchronic PY administration.

3. Recovery from hemorrhagic and burn shock can be obtained with 1/20th the volume of HSD as would be required for similar recovery with isotonic solutions. This study determined the effects of HSD administration on fluid distribution following dehydration. Female Yucatan micropigs (2 groups of 9) were housed in stainless steel cages in an environmental chamber at 23°C. Experimental procedure was as follows: 23°C, withdraw food and water (4 hr) * 33°C, dehydration (23 hr) * 4ml/kg HSD or saline (1 hr) * 23°C return of water (20 hr) *. At each of the times marked by an "*", weight and rectal temperature were measured and Vascular Access Ports were used to obtain plasma samples for Na^+, K^+, osmolality and plasma volume (via

indocyanine green) determinations. Dehydration at 33°C resulted in: significantly increased core temperature (37.2 ± 0.2 (mean ± SE) to 39.0 ± 0.1°C) and decreased body weight (4.4 ± 0.4%) and plasma volume (PV, 1022 ± 46 to 835 ± 29 ml). HSD but not saline administration resulted in significant increases in PV (1047 ± 61 ml), sodium concentration (141 ± 1 to 150± 2 mEq/l) and osmolality (291 ± 2 to 307 ± 11 mOsm) over dehydration levels. Following return of water, values returned to baseline levels for both groups. Since insensible (respiratory and trans-dermal) water loss for the 24 hours at 23°C was 714 ± 64ml and for the 24 hours at 33°C was 653 ± 64ml, increasing the ambient temperature did not result in increased dehydration in swine. HSD administration restored PV to baseline levels despite prior water loss dehydration.

4. Recent reports implicate cytokines such as IL-1 and TNF in tissue injury and repair, the inflammatory response, the immune response, shock, fever, sunburn, endothelial cell senescence, and programmed cell death. The skin generally provides a protective barrier between the environment and sensitive internal tissues of the body; however, skin cells, particularly keratinocytes which cover the entire body surface, have a high capacity for production of cytokines and other regulatory substances. A unique approach to research on the effects of heat on humans was developed using artificial human skin. This study was designed to: determine whether heat-induced injury to Skin[2] results in release of IL-1α, TNF-α, K^+ and prostaglandins (PGE_2 and TxB_2) which may contribute to either or both injury and repair; identify the heat load (time/temperature) required to induce release of these substances; use the nuclear matrix apparatus protein to compare levels of dead or dying cells in control and heated groups; use immunohistochemistry and immunogold labelling to localize soluble and bound IL-1α and IL-1α receptors by light and electron microscopy; confirm induction vs. constitutive pools or membrane bound IL-1α in control and heated tissue by using <u>in situ</u> hybridization of IL-1α mRNA with commercially available IL-α mRNA probes; use a bioassay to confirm biological activity of IL-1α after quantitative detection by antigen specific assay; and relate findings to heatstroke in humans and to other injuries which involve autocrine (self stimulation), paracrine (local stimulation), or endocrine (remote stimulation) effects of these regulatory factors.

USARIEM
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PUBLICATIONS:

1. Bowers, W., M. Blaha, J. Sankovich, D. Patterson, and D. DuBose. Release of prostaglandin E_2, interleukin-1d and K^+ from artificial human skin after freezing. Cryobiology, (In Press), 1992.

2. DuBose, D.A. and J.W. Agnew. Seasonal effects on human physiological adaptation factors, thermotolerance and plasma fibronectin. Aviation, Space, and Environmental Medicine, 63:982-985, 1992.

3. DuBose, D.A. and R. Haugland. In situ and in vitro comparisons of endothelial cell G- and F-actin distribution. Biotechnic and Histochemistry. (In Press), 1992.

4. Matthew, C.B., R.P. Francesconi, and R.W. Hubbard. Physostigmine: dose-response effects on endurance and thermoregulation during exercise. Life Sciences, 50:39-44, 1992.

5. Matthew, C.B. An animal model of drug-induced thermoregulatory and endurance decrements. Proceedings of 1992 Army Science Conference, pp. 315-326, 1992.

6. Matthew, C.B. Ambient temperature effects on thermoregulation and endurance in anticholinesterase-treated rats. Life Sciences. (In Press), 1992.

ABSTRACTS:

7. DuBose, D.A., D.H. Morehouse, and J.R. Hinkle. Bovine aortic endothelial cell (BAEC) barrier function following hyperthermic exposure. FASEB Journal, 6:A1035, 1992.

8. Matthew, C.B. Treatment of hyperthermia and dehydration with a hypertonic solution. FASEB, Anaheim, CA, 5-9 April 1992.

PRESENTATIONS:

9. Matthew, C.B., D. Patterson and T. McPherson. Treatment of hyperthermia and dehydration with hypertonic saline in

dextran (HSD). SALT-5 International Meeting on Resuscitation with Hypertonic Solutions, Galveston, TX, 3-5 June 1992.

10. Matthew, C.B. An animal model of drug-induced thermoregulatory and endurance decrements. 18th Army Science Conference, Orlando, FL. 22-26 June 1992.

KEY BRIEFINGS:

11. Bowers, S.D. Major General Chi Woo Lee, Commander, Armed Forces Medical Command, Republic of Korea. 21 July 1992.

12. Bowers, W.D. Colonel Peter F. Lutter, British Medical Liaison Officer, Office of the Surgeon General. 1 September 1992.

13. Matthew, C.B. Environmental Pathophysiology Directorate Overview and Chemical Defense Animal Program. For Joseph Meyerovitch, M.D., NBVC Branch Head, IDF Medical Corps; Lt. Col. Duer Ytzhak, Ph.D., NBC Protection Division, State of Israel - Ministry of Defence, Directorate of Defence R&D, Hakirya, Tel Aviv; and Gabriel Amitai, Ph.D., Head, Division of Chemistry, Israel Institute for Biological Research, P.O. Box 19, 70450 Ness-Ziona, Israel. USARIEM, Natick, MA. 30 March 1992.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Bowers, Wilbert D., Ph.D., Division Chief. Treasurer, New England Society for Electron Microscopy.

DuBose, David A., Ph.D., Chairperson, Program Committee, Natick Chapter, Sigma Xi, The Research Society.

Matthew, Candace B., MAT, Research Biologist. Secretary, Natick Chapter Sigma Xi, July 1992 - June 1993. Reviewer, Aviation, Space and Environmental Medicine, and Life Sciences. Science Fair Judge for Sigma Xi.

USARIEM
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ENVIRONMENTAL PHYSIOLOGY & MEDICINE DIRECTORATE

RESEARCH FINDINGS: EXECUTIVE SUMMARY

- Voluntary, isolated muscle function of soldiers exposed to altitude for 18 days was impaired during acute exposure, improved with chronic exposure, and returned to normal one day after return to sea level.

- The effect of exercise on the incidence and severity of acute mountain sickness was studied in soldiers exposed to altitude for 36 h. Exercise did not alter the rate of onset and caused no significant change in symptom severity and incidence.

- Voluntary consumption of a carbohydrate supplement and a pre-packed field ration was measured in soldiers during a strenuous winter field training exercise at moderate altitude. Soldiers consumed only 58% of their estimated energy needs without the supplement and 89% with the supplement, indicating the desirability of including a carbohydrate supplement to energy-demanding field training exercise.

- Visual function was studied before and after steady-state exercise in subjects exposed to altitude for three weeks. There were no evident changes in visual function or in visual evoked potentials. There were significant reductions in intraocular pressures after four days which persisted for the entire exposure. The measurement of intraocular pressure may represent a method to monitor changes in altitude-induced cerebral circulation.

- Data collection was completed on a 17-day high altitude acclimatization study evaluating cardiovascular, ventilatory, body fluid, and visual responses during rest and exercise. The persistence of altitude acclimatization was studied by re-exposing soldiers to altitude following 10 days at sea level.

- Three compact, lightweight, microprocessor-based ambulatory monitors have been developed and are in

different stages of validation: a core temperature monitor which utilizes an FDA-approved radiotelemetry pill; a canteen "drink-o-meter", which can be used to measure soldier water intake in the field, and a stride meter, based on body mass and foot-ground contact time that will estimate soldier energy expenditure during walking and running.

- To verify whether caffeine administration would improve soldier physical performance on a high altitude hike (Pikes Peak), Special Operations Forces (SOF) soldiers performed a timed hike from 1800m to 4300m. There was no difference found between the caffeine and control groups.

- Completed CBR clothing/exercise studies in a hypobaric environment characterizing critical heat exchange factors important at high terrestrial altitude.

- Determined the effects of hypoxia on regional skin blood flow responses in heat-stressed men exercising at a moderate intensity in a control (sea level) and a hypoxic, hypobaric (10,000 ft.) environment.

- Conducted biophysical evaluation of intermediate cold-wet glove system detailing thermal resistance of potential handwear items.

- Initiated a human study to be conducted at the Cold Regions Research and Engineering Laboratory (CRREL), New Hampshire on optimum intermediate glove.

- Conducted a epidemiological cold injury study in Alaska.

- Conducted (collaborative with Naval Health Research Center {NHRC}) field study on dehydration and cold injury susceptibility at Marine Mountain Warfare Training Center.

- Demonstrated efficacy of the food supplement pack to increase caloric intake during operations in the cold.

- Conducted cold weather field evaluation of the 18-man Arctic Tray Pack Ration Module.

- Described the effects of sunburn on thermoregulation of soldiers during exercise in the cold.
- Delineated the role of exercise intensity and gender on thermoregulation during cold-water immersion.
- Reviewed the effects of alcohol ingestion on thermoregulation in the cold.
- Reviewed the effects of menstrual cycle and gender on thermoregulation in the cold.
- Developed and distributed a Technical Note on cold injury prevention during cold weather operations.
- Reviewed the biophysics and mechanisms of heat transfer for clothing materials.
- Ascertained the heat transfer characteristics of U.S. Marine Saratoga, Phase I, Soldier Integrated Protective Ensemble and Advanced *Battledress Overgarment* Systems, and performed model predictions to wide environmental stress of each system.
- Completed field measurements of physiological strain and biometeorological factors for modeling soldier performance characteristics.
- Initiated analysis of 30 weather satellite passes and ground truth data evaluations from the field study at FT Bliss for heat stress model-prediction schemes.
- Initiated joint effort with Battlefield Environment Directorate, ARL-WS, to exploit surface and satellite-derived weather data for heat injury risk assessment.
- Four prototype heat stress monitors with environmental sensor units and USARIEM heat strain algorithms were fabricated by Southwest Research Institute (San Antonio, TX), under contract by USAMMDA.
- Evaluated the heat strain of the Soldier Integrated Protective Ensemble (SIPE).

- Evaluated the heat strain of the Chemical Protective Undergarment for Natick RD&E Center.
- Characterized the incidence of heat exhaustion for a given level of physiological strain in soldiers when euhydrated and hypohydrated (-8% of total body water).
- Described the effects of sunburn on thermoregulation of soldiers during exercise in the heat.
- Characterized the role of thermal factors on aerobic capacity improvements from exercise training.
- Characterized physiologically the relative importance of hypovolemia and hypertonicity for adverse thermoregulatory responses in dehydrated soldiers.
- Reviewed the effects of menstrual cycle and gender on thermoregulation in the heat.
- Determined the thermoregulatory impact of a topical antipenetrant (TAP, niclosamide lotion, 1% emulsion) application on heat-acclimated men working in a hot environment.
- Delineated the validity of "pill" technology to measure core temperature during exercise-heat stress.
- Developed normative data for the erythrocyte, plasma and blood volume of healthy male soldiers. Plasma and erythrocyte volumes were measured by radioactive labeling methodologies.

PUBLICATIONS:

1. Pandolf, K.B., R.W. Gange, W.A. Latzka, I.H. Blank, K.K. Kraning and R.R. Gonzalez. Human thermoregulatory responses during heat exposure after artificially-induced sunburn. American Journal of Physiology, 262:R610-R616, 1992.

2. Pandolf, K.B., R.W. Gange, W.A. Latzka, I.H. Blank, A.J. Young and M.N. Sawka. Human thermoregulatory responses during

cold-water immersion after artificially-induced sunburn. American Journal of Physiology, 262:R617-R623, 1992.

3. Pandolf, K.B. and A.J. Young. Environmental Extremes and Performance. In: Sports and Human Endurance. P.O. Astrand and R.J. Shepherd (Eds.). Blackwell Scientific Publications, Ltd., Oxford, pp. 270-282, 1992.

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5. Pandolf, K.B. Heat tolerance and aging. Experimental Aging Research, 18: (In Press), 1992.

6. Pandolf, K.B. and A.J. Young. Altitude and Cold; The Cardiac Patient. Heart Disease and Rehabilitation. 3rd Edition, M.L. Pollock and D.H. Schmidt (Eds.). Human Kinetics Publishers, Inc., Champaign, IL. (In Press), 1992.

ABSTRACTS:

7. Pandolf, K.B. Prediction of Digital and Whole-Body Responses in Humans During Cold Exposure. Paper delivered at Symposium entitled, Understanding Thermal Balance in the Cold, Second Annual Winter Wilderness Medicine, Big Sky, Montana, March 1992.

8. Pandolf, K.B. Modeling of Physiological Responses and Human Performance in the Heat. Paper delivered at the American College of Sports Medicine Symposium entitled, The Challenge of Exercise Wearing Biological and Chemical Warfare Protective Clothing, Dallas, TX, May 1992.

PRESENTATIONS:

9. Pandolf, K.B. Environmental Factors Affecting Performance, Luncheon Lecture at the U.S. Army War College, Carlisle Barracks, PA, April 1992.

10. Pandolf, K.B. Environmental Physical Stress: High Altitude, Cold and Heat. Lecture as part of Advanced Course entitled, Fitness of the Army. U.S. Army War College, Carlisle Barracks, PA, April 1992.

11. Pandolf, K.B. Modeling of Physiological Responses and Soldier Performance in the Heat. Seminar before the Technical Panel UTP-6 (Physiological and Psychological Aspects of Personnel Protection) of The Technical Cooperation Program, U.S. Army Research Institute of Environmental Medicine, Natick, Massachusetts, June 1992.

12. Pandolf, K.B. Overview of the Development of the USARIEM Heat Strain Model. Integrated Performance Modeling of Soldier System Symposium, U.S. Army Natick Research, Development and Engineering Center, Natick, Massachusetts, September 1992.

SIGNIFICANT VISITORS:

Dr. Michael A. Stroud, Applied Physiology Division, Army Personnel Research Establishment, Ministry of Defence, Farnborough, United Kingdom.

Dr. W.R. Withey, Chairman, The Technical Cooperation Program, Army Personnel Research Establishment, Ministry of Defence, Farnborough, United Kingdom.

Dr. Lawrence C. Berglund, The John B. Pierce Foundation Laboratory, New Haven, CT.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Pandolf, Kent B., Ph.D., Research Director. Adjunct Professor of Health Sciences, Department of Health Sciences, Sargent College of Allied Health Professions, Boston University, Boston, MA; Adjunct Clinical Professor of Sports Biology, Springfield College, Springfield, MA; Vice-President and Board of Directors, International Society for Adaptive Medicine, Freiburg, FRG. Chairman, Publications Committee, American College of Sports Medicine. Counselor, Steering Committee, Environmental and Exercise Physiology Section, The American Physiological Society; Editorial Board Member, Ergonomics, Exercise and Sport Sciences Reviews, Medicine and Science in

Sports and Exercise. Guest Book Reviewer: Sports Medicine Bulletin. Reviewer: Medicine and Science in Sports and Exercise, Journal of Applied Physiology, American Journal of Physiology: Regulatory, Integrative and Comparative Physiology, Perceptual and Motor Skills, The Physician and Sportsmedicine, Journal of Cardiac Rehabilitation, International Journal of Sports Medicine, European Journal of Applied Physiology and Occupational Physiology, Journal of Sport Psychology, Aviation, Space and Environmental Medicine, New York State Journal of Medicine, The American Journal of Clinical Nutrition, Undersea Biomedical Research, and Pediatric Exercise Science.

ALTITUDE PHYSIOLOGY & MEDICINE DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

1. An experimental ergometer was developed which totally isolates the adductor pollicis muscle during static muscle contractions. The device allows a subject to periodically provide a maximal voluntary contraction during the conduct of submaximal, static contractions at any level of muscle force so that rate of muscle fatigue can be quantitated. The device has been used for the study of muscle fatigue and muscle endurance in hypoxia.

2. In order to determine the effects of altitude exposure on voluntary muscle strength and endurance of the adductor pollicis muscle during submaximal exercise, eight male soldiers were studied before, during, and after residing at altitude (4300 m) for 20 days. Muscle endurance performance, but not strength, was affected during and following altitude residence. Endurance performance was decreased during early altitude exposure; improved after two weeks; increased further immediately after returning to sea-level, but then returned to baseline levels. The decrement in performance at altitude is consistent with the concept that increases in lactic acid and hydrogen ion production interfere with muscle force production. The subsequent improvement at altitude may be due to a combination of reduced lactate production, an increase in

sympathetic activity, and/or alkalosis. The improvement in endurance performance immediately following exposure is also consistent with a sustained, but transitory, decrease in muscle lactate concentration during exercise, higher levels of circulating catecholamines, and alkalosis.

3. Cardiovascular changes such as reductions in plasma volume and stroke volume, and increases in heart rate and blood pressure with exposure to high altitude are well documented. How these physiological changes affect responses to a circulatory challenge, such as a change in body position during and following altitude exposure is not well known. It was hypothesized that the altitude-induced reduction in plasma volume would be directly related to changes in the responses to upright tilt during and after long-term altitude exposure. Eleven male soldiers (mean age: 25.6 yr) performed passive tilt-table tests (20 min supine; 20 min upright) before, during (days 2 and 14), and after (within 24 hours of return) 20 days of residence at altitude (4300 m). Heart rate, stroke volume (impedance cardiography), hematocrit, hemoglobin, and blood pressure were measured every five minutes during each tilt-table test. In response to the change in body position, heart rate and blood pressure increased, and stroke volume and plasma volume decreased. Preliminary analyses indicate that the magnitude of change in each of these parameters differed depending upon the day of the tilt-test. The data also suggest that reduction in plasma volume from pre-exposure levels is not the primary factor contributing to the change in responses to upright tilt after exposure. When compared to sea-level values, plasma volume had decreased by 9% and 20% on the 2nd and 14th day of exposure, respectively. Consistent with these reductions, stroke volume and heart rate responses to tilt were also reduced. Within 24 hours of returning to sea level, the stroke volume, heart rate, and blood pressure responses to tilt were nearly identical to pre-exposure values, yet plasma volumes were still reduced by 16%. These findings appear to contradict our hypothesis.

4. Venous occlusion plethysmography was used to measure forearm blood flow in 10 soldiers at rest and during six minutes of leg-cycling exercise before, during, and after 20-days exposure to altitude (4300 m). The same relative exercise intensity (75% of maximal oxygen consumption) was

maintained throughout the study. Daily changes in plasma volume were calculated prior to testing using hematocrit and hemoglobin values. Resting forearm blood flows (ml/dl - tissue/min) prior to and during early altitude exposure were similar (mean: 2.87 vs 2.70) but were higher than during long-term altitude exposure (1.97, $p<0.05$). Resting forearm blood flow following exposure did not differ from values before exposure. Exercise forearm blood flow was reduced throughout altitude exposure but recovered immediately upon returning to sea level. Plasma volume was decreased by 10.1% on day 3 and 24.5% on day 12 at altitude, and 15.0% on the first day after returning to sea level. These results indicate that: (a) forearm blood flow at altitude during rest, but not exercise, parallels changes in plasma volume, and (b) forearm blood flow during rest and exercise after altitude exposure returns to pre-exposure levels even though plasma volume does not.

5. The time course and expression of a wide variety of physiological changes during altitude acclimatization have been well studied. Not well studied, however, are the processes of de-acclimatization to altitude, and the physiological responses accompanying reintroduction to high altitude following recent residence at high altitude. Since ventilatory acclimatization to altitude is a gradual process spanning weeks, de-acclimatization might span a similar period. We hypothesized that some degree of ventilatory acclimatization would be retained upon reintroduction to altitude (RA) eight days following return to sea level (SL). We measured the metabolic and ventilatory parameters of six male lowlanders during rest and submaximal exercise at SL, acute altitude (AA), after 16 days residence at 4300 m on Pikes Peak (PP), and during a 24-hr RA after eight days at SL. Ventilatory acclimatization produced an increase (PP vs AA, $P<0.05$) in VE/VC02 and Sa02 at all oxygen uptakes studied. After eight days at SL, subjects reintroduced to altitude demonstrated a retention of approximately 90% and 67% of their acclimatization responses for ventilation and arterial oxygenation, respectively. These results suggest that ventilatory de-acclimatization to altitude is a gradual process, likely spanning several weeks. Thus, hypoxic stress is reduced during subsequent returns to altitude within that time period.

6. Acute mountain sickness (AMS) symptomatology declines as high altitude acclimatization progresses. We hypothesized that partial retention of acclimatization would attenuate the severity of AMS upon reinduction to altitude (RA). Five male lowlanders were studied during a 16-day stay at Pikes Peak (PP)(4300 m). At that time they were determined to be acclimatized and returned to sea level (SL). After 8 days they underwent RA for 30 hrs in a hypobaric chamber. AMS-C symptomatology scores (±SD), determined by the Environmental Symptoms Questionnaire (ESQ), were: 0.73±0.40(PP1); 0.66±0.19(PP3); 0.08±0.08(PP6); 0.00±0.00(PP9); 0.03±0.10 (PP15); and 0.27±0.06 (RA). The AMS-C scores were reduced during RA when compared to PP1 ($p< 0.05$). Possible mechanisms include: 1) the hypoxic stress was less with RA than at PP1 (RA SaO_2=85±3, PP1=75±6, $p<0.05$), 2) plasma volume was reduced by 20% with RA and only 11% at PP1. These results suggest that the retention of acclimatization after eight days at SL is sufficient to attenuate AMS symptomatology upon reinduction.

7. Laboratory studies have shown that submaximal endurance exercise capacity, and possibly the gross efficiency of exercise (total power output/total metabolic energy expenditure), increase after altitude acclimatization. This has been verified on Pikes Peak (4300m). Eight males (age = 29±3 y ($\bar{X}$±SD), wt = 85.4±12.8 kg) were studied during two competitive ascents of Pikes Peak (1875 to 4300 m) via the 22 km Barr Trail, once before and once after 10 days of acclimatization to 4300 m. Total power output in kJ equals the product of the subject's total weight in Newtons and the 2425 m change in elevation. Oxygen uptake ($\dot{V}o_2$, $L \cdot min^{-1}$), estimated from minute-to-minute heart rate (HR) monitor records and the relationship of submaximal $\dot{V}o_2$ to HR determined before and after acclimatization, was used to calculate metabolic energy expenditure. Pre- vs. post-acclimatization values were: $\dot{V}o_2$ = 2.69±0.47 vs. 2.62±0.31 $L \cdot min^{-1}$ ($P>0.05$); finishing time = 288±38 vs. 247±35 min ($P<0.05$); gross efficiency = 13.4±1.7 vs 15.2±1.6 % ($P<0.05$). These results confirm earlier reports that acclimatization to high altitude improves submaximal endurance exercise performance and increases the gross efficiency of exercise.

8. A new electronic monitor to estimate the metabolic cost of locomotion of soldiers in the field by measuring time of foot contact has been developed and tested. Using this device, we derived and validated an equation for estimating the metabolic cost of locomotion from body weight and the time during each stride that a single foot contacts the ground. Twelve males were tested (mean±SD: age = 19.4±1.4 yr; body weight = 78.4±8.0 kg) during horizontal treadmill walking (0.89, 1.34, 1.79 $m \cdot s^{-1}$) and running (2.46, 2.91, 3.35 $m \cdot s^{-1}$). The measured metabolic cost of locomotion was defined as total energy expenditure, measured by indirect calorimetry, minus estimated resting energy expenditure. The equation to estimate the metabolic cost of locomotion was derived in six randomly selected subjects: metabolic cost of locomotion = 3.766·(body weight/foot contact time) - 162.3 ($r^2 = 0.97$). Cross-validation in the remaining six subjects showed that estimated and measured metabolic cost of locomotion were highly correlated ($r^2 = 0.98$). The average individual error between estimated and measured metabolic cost of locomotion was -1% (range = -21% to +29%). It was concluded that the metabolic cost of locomotion can be estimated with reasonable accuracy from body weight and foot contact time measurements made by an ambulatory foot contact monitor.

9. Previous altitude expedition studies have shown either no change or reductions in intra-ocular pressure (IOP), with decreases lasting two weeks after return to sea level. IOPs were measured using a noncontact tonometer in 11 resting male lowlanders (aged 29±1 yrs, $\bar{X}$±SE) during acute hypobaric hypoxia (<2h, hypobaric chamber, AA), after altitude acclimatization (15d at 4300m, HA), and in six of the 11 volunteers, during a <2h re-exposure to hypobaric hypoxia 8d after return to sea level (RA). Compared to SL, AA resulted in a 20% decrease in IOP (15.8±0.6 vs 12.9±0.9 mmHg, P<0.001). During the HA phase, a nadir was reached after 2d (11.8±0.7 mmHg, P<0.001 vs SL) after which there was a gradual increase toward SL values. After 15 days, IOP was still reduced (14.0±0.8, P<0.04). Within one day of return to SL, IOP was normal. During RA, IOP was again reduced 20%. During HA, IOP followed a pattern inverse to symptoms of acute mountain sickness (AMS). In 9 of 11 subjects, the decrease in IOP was correlated with the severity of AMS, as determined by Environmental Symptom Questionnaire (y = 0.077x - 0.035,

r=0.71). These results indicate that the altitude-induced IOP reduction is relatively rapid and undergoes an acclimatization phenomenon which does not persist after eight days at sea level.

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1. Anholm, J.D., A.C. Powles, R. Downey, C.S. Houston, J.R. Sutton, M.H. Bonnet and A. Cymerman. Operation Everest II: arterial oxygen saturation and sleep at extreme simulated altitude. American Review Respiratory Disease, 145:817-826, 1992.

2. Brooks, G.A., E.E. Wolfel, B.M. Groves, P.R. Bender, G.E. Butterfield, A. Cymerman, R.S. Mazzeo, J.R. Sutton, R.R. Wolfe and J.T. Reeves. Muscle accounts for glucose disposal but not blood lactate appearance during exercise after acclimatization to 4,300 m. Journal of Applied Physiology, 72:2435-2445, 1992.

3. Claybaugh, J.R., D.P.Brooks, and A. Cymerman. Hormonal Control of Fluid and Electrolyte Balance at High Altitude in Normal Subjects. In: Hypoxia and Mountain Medicine, edited by Sutton, J.R., Coates, G. and Houston, C.S. (Eds.) Burlington: Queen City Printers, Inc., pp. 61-72, 1992.

4. Forte, V.A.,Jr., J.A. Devine, P.B. Rock and A. Cymerman. The use of tympanometry to detect aerotitis media in hypobaric chamber operations. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report T5-92.

5. Fulco, C.S., R.W. Hoyt, C.J. Baker-Fulco, J. Gonzalez and A. Cymerman. Use of bioelectrical impedance to assess body composition changes at high altitude. Journal of Applied Physiology, 72:2181-2187, 1992.

6. Reeves, J.T., L.G. Moore, E.E.Wolfel, R.S.Mazzeo, A.Cymerman, and A.J. Young. Activation of the sympatho-adrenal system at high altitude. In: High Altitude Medicine, edited by Ueda, G. Matsumoto, Japan: Shinshu University, pp. 10-23, 1992.

7. Young, P.M., J.R. Sutton, H.J. Green, J.T. Reeves, P.B. Rock, A. Cymerman and C.S. Houston. Operation Everest II: metabolic and hormonal responses to incremental exercise to exhaustion. Journal of Applied Physiology, 73:2574-2579, 1992.

ABSTRACTS:

8. Fulco, C.S., L.A. Trad, V.A. Forte, Jr., J. Gonzalez, E.J. Iwanyk, R.W. Hoyt and A. Cymerman. Use of an hypoxic and carbon dioxide sensitivity test to predict the incidence and severity of acute mountain sickness (AMS) at moderate altitude (3800 m). FASEB Journal, 6:A1773, 1992.

9. Hoyt, R.W., C.S. Fulco, M.J. Durkot, T.P. Stein, and A. Cymerman. Effects of high altitude residence on lactate metabolism during exercise. FASEB Journal, 6:A1467, 1992.

10. Iwanyk, E.J., S. Smith, B.A. Beidleman, J.L. Kobrick, A. Roberts and A. Cymerman. Effects of prolonged high altitude exposure on intraocular pressure, visual fields, acuity, vergence, phoria, and visual evoked response. FASEB Journal, 6:A1773, 1992.

11. Kamimori, G.H., T.J. Balkin, N.J. Wesensten, J. Crowley, N. Pearson, E. Iwanyk and A. Cymerman. The effect of triazolam on sleep architecture during acute exposure to high altitude (4300 m). Medicine and Science in Sports and Exercise, 24:S156, 1992.

12. Mazzeo, R.S., G.A. Brooks, G. Butterfield, A. Cymerman, R. Grover, A.C. Roberts, M. Selland, E.E. Wolfel and J.T. Reeves. Influence of β-adrenergic blockade on the metabolic responses to exercise at high altitude. Medicine and Science in Sports and Exercise, 24:S90, 1992.

13. Mazzeo, R.S., G.A. Brooks, A. Cymerman, D.A. Podolin, M. Selland, E.E. Wolfel and J.T. Reeves. Catecholamine differences across exercising and non-exercising muscle: influence of beta-blockade. FASEB Journal, 6:A1465, 1992.

14. Roberts, A.C., G.A. Brooks, G.E. Butterfield, A. Cymerman, R. Mazzeo, E.E. Wolfel and J.T. Reeves.

Beta-blockade does not affect arterial glucose concentration during rest and exercise at sea level or 4,300 m altitude. Medicine and Science in Sports and Exercise, 24:S89, 1992.

15. Wesensten, N., T. Balkin, G. Kamimori, J. Crowley, E. Iwanyk, N. Pearson, D. Kaufman, P. Amoroso, G. Belenky and A. Cymerman. Altered daytime sleep latency during exposure to simulated altitude (4300 M). 11th European Congress on Sleep Research, Helsinki, Finland, 1992.

16. Wolfel, E., M. Selland, R. Grover, A. Cymerman, G. Brooks, G. Butterfield, R. Mazzeo and J.T. Reeves. Beta-adrenergic influences on submaximal exercise hemodynamics with acclimatization at 4300 m. FASEB Journal, 6:A1467, 1992.

17. Wolfel, E.E., M. Yaron, M. Selland, R.S. Mazzeo, A. Cymerman, R. Grover and J.T. Reeves. Increases in systemic arterial pressure after 3 weeks residence at 4300 m. A sympathetic effect. Clinical Research, 40:A22, 1992.

18. Yamamoto, Y., R.L. Hughson, J.R. Sutton, C.S. Houston and A. Cymerman. Deterministic chaos in human heart rate variability at simulated extreme altitude. FASEB Journal, 6:A1528, 1992.

PRESENTATIONS:

19. Hoyt, R.W., Ph.D. Energy balance in soldiers during Ranger Training Course. National Academy of Science Committee on Military Nutrition, Washington, D.C., February 1992.

20. Hoyt, R.W., Ph.D. Energy balance in extreme environments. Massachusetts Institute of Technology nutrition students. February 1992.

KEY BRIEFINGS:

21. Cymerman, A. Ph.D., to T.S. Brig Shergill, Military Attaché India, at Natick Research, Development and Engineering Center, on Cooperation between USARIEM scientists and the Indian Army, September 1992.

22. Iwanyk, E.J., MAJ, M.D., to Naval Undersea Medical Institute, New London, Connecticut, on Medical Support of Military Operations at High Altitude, February 1992.

23. Rock, P.B., LTC, O.D., Ph.D., to Naval Undersea Medical Institute, New London, Connecticut, on Medical Problems at High Altitude, February 1992.

24. Rock, P.B., LTC, O.D., Ph.D., to University of Massachusetts Medical Center, Worcester, Massachusetts on Acute Mountain Sickness, February 1992.

25. Rock, P.B., LTC, O.D., Ph.D., to Naval Undersea Medical Institute, New London, Connecticut, on Medical Problems and Medical Support in Military Operations at High Altitude, July 1992.

SIGNIFICANT TDY:

Allen Cymerman, Ph.D. Briefing to Command Surgeon, COL William F. Hughes, U.S. Special Operations Command, MacDill Air Force Base, Florida, Mission and Medical Research, Projects of the Altitude Physiology and Medicine Division, January 1992.

SIGNIFICANT VISITORS:

John M. Kinney, M.D., Visiting Professor, The Rockefeller University, New York, February 1992.

Robert D. Reynolds, Ph.D., Associate Professor, Dept. of Nutrition, Univ. of Illinois at Chicago, Illinois, March 1992.

T. Peter Stein, Ph.D., Professor of Surgery, Univ. of Medicine and Dentistry of New Jersey, Camden, NJ, April 1992.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Allen Cymerman, Ph.D., Division Chief. Adjunct Associate Professor, Sargent College of Allied Health Professions, Department of Health Sciences, Boston, MA. Member, Editorial Board, Wilderness Medical Society.

Reed Hoyt, Ph.D. Co-Chair and organizer of the 1992 American Physiological Society Hypoxia Interest Group. Secretary and Representative, Program Advisory Committee for the Hypoxia Interest Group.

BIOPHYSICS & BIOMEDICAL MODELING DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

1. A field study was conducted on eight soldiers in which physiological responses and with accompanying biometeorological parameters were collected for the modeling of soldier performance and thermal ground features. Soldiers simulated 6h, 12-mile marches dressed in MOPP 0, MOPP 1 and MOPP 4 uniforms during August at FT Bliss, TX. A general agreement (varying only within an overall mean prediction error of -0.2 to 0.43°C), was obtained between observed subject rectal temperatures (T_{re}) and the P^2NBC^2 Heat Strain Decision Aid (HSDA) model. Comparison of data from heat stress monitors and the observed physiological responses indicated that small differences in wind speed and humidity provided significant effects on soldier performance during simulated field tests. It is concluded that soldier thermal strain responses can be exquisitely sensitive to relatively subtle differences in weather conditions. This sensitivity is consistent with USARIEM's Heat Strain Model predictions. Prototype environmental heat stress monitors were delivered to USARIEM and tested. Satellite image processing hardware and software were acquired and training on satellite data processing was completed.

2. Biophysical evaluations were conducted on chemical protective overgarments (CPOs) for the U.K. Army and U.K. Navy; U.S. Army and U.S. Air Force, and Canadian Armed Forces as part of The Technical Cooperation Program (TTCP). Garments from the United Kingdom and the U.S. Army offered the least thermal insulation and highest evaporative potential of current CPOs.

3. A study was conducted on biophysical properties of chemical protective textile materials for the U.S. Army Advanced Overgarment Program. The lowest thermal resistance values were measured in samples possessing Saratoga-PBI absorptive fibers in combination with NYCO and Tri-Blend materials.

4. Biophysical evaluations and heat strain modeling were conducted in support of the Soldier Integrated Protective Ensemble (SIPE) and for the USMC Saratoga Program. It was found that the SIPE I configuration, incorporating the Advanced Concept Combat uniform shell plus chemical vapor undergarment, had lower thermal insulation but higher evaporative potential, than the U.S. Army Woodland BDU plus BDO configuration.

5. A biophysical and human physiological evaluation of the extended cold-weather glove system was conducted. Evaluations of prototypes on a 9-heated zone metallic hand manikin indicated that an intermediate cold-wet glove, with 90 gram, 3M Liteloft material, approached 89% of the thermal insulation values found in the standard Arctic mitten.

6. Work progressed on the development of a cold weather heat-transfer model. A lumped parameter model of a finger tip (the anatomical site that is most susceptible to cold injury) was developed. A successful analytical solution to the effects of cold induced vasodilation (CIVD) was obtained, in which the critical phenomenon is simulated by a series of symmetrical triangular wave patterns depicting the behavior of finger skin blood flow upon exposure to cold.

7. A study was done focusing on ways of ascertaining heat-strain endurance limits of a lightweight protective overgarment (USMC Saratoga, {SARATOGA}) in comparison to the U.S. Army BDO. A Statement of Need-Clothing and Individual Equipment (SN-CIE) related to the SARATOGA overgarment originally stated that this garment should: "Increase by at least 20 percent (30 percent desired) relative to the BDO, the amount of time a soldier can wear the garment in Mission Oriented Protective Posture (MOPP) level 4, and not exceed a body core temperature of 39°C while engaged in heavy activity at an ambient temperature of 65°F, 70% rh, and under direct

solar load." Our prediction modeling, using copper manikin data incorporated into the USARIEM Heat Strain Model, found that, in climatic zones from 68°F to 90°F, 50 to 75% rh and at 1 and 10 mph wind speed, the SARATOGA would exceed or provide the 20 percent required by the SN-CIE. At 90°F up to 120°F, with 20 up to 50% rh, however, both the SARATOGA and U.S. BDO were found to have similar (non-significant differences) stay times depending on work intensity. The latter results are based on the fact that heat buildup in CB clothing systems resulting from work cannot be dissipated adequately in the closed configuration.

8. A sweating flat-plate analysis was conducted on protective materials for the U.S. Army Advanced Battle Dress Overgarment program. It was found that the Saratoga PBI material had significantly lower thermal resistance and water vapor resistance values, compared to similar configurations employing the standard, 50-mil, charcoal-foam absorbent layer.

9. In view of the above flat-plate results, copper manikin studies were conducted to ascertain whether the thermal characteristics of the new Advanced Battle Dress Overgarment (ABDO) candidates differed from the current standard Woodland BDO. The ABDO candidates consisted of the following prototype clothing systems: a) 4.5 oz NYCO shell with a Saratoga liner; b) a 4.5 oz NYCO shell with a 50-mil foam liner; c) a 6 oz NYCO shell with a Saratoga liner; d) a 6 oz NYCO shell with a 50-mil foam liner; e) a Gore-Tex shell with a Saratoga liner; f) a Gore-Tex shell with a 50-mil foam liner; g) a Triblend shell with a Saratoga liner; h) a Triblend shell with a 50-mil foam liner; i) a Repel shell with a Saratoga liner; j) a Repel shell with a 50-mil foam liner along with the control; and, k) Woodland BDO with 90-mil foam liner. Manikin evaluations for dry insulation (clo) and vapor permeability (i_m) were conducted with environmental conditions set at 70°F dry-bulb temperature, and a relative humidity of approximately 50%. Wind velocities were varied between 0.9 and 5.0 mph to measure changes in clo and in i_m of these semipermeable and impermeable membranes. Results showed that the Saratoga liner provided slightly higher evaporative potential (i_m/clo) than garments with the 50-mil foam liners under all configurations but one. The exception was the configuration which used the Repel shell. The Repel shell with 50-mil foam liner gave

slightly better evaporative potentials at 0.9 and 2.5 mph but not at 5.0 mph.

10. Successful β-site testing and response consolidation from potential users of the Ada-language version of the USARIEM Heat Strain Model was accomplished by Science Applications International Corporation (SAIC) for a P^2NBC^2-sponsored project. This project has been completed, contingent on the final consolidation and changes to clothing menu data by EMB technical input and other user response recommendations. The conversion of the current calculator version of USARIEM Heat Strain Model to Ada programming mode for use as a tactical decision aid should now provide military users with an executable file capable of being run in a wide variety of desk-top computer systems using DOS. The user will be able to test various challenges that the soldier experiences while exposed to heat stress in various military clothing ensembles.

11. Work continued on the testing of three modeling approaches by Geo-Center, Inc. comparing various computer algorithms incorporating prediction analysis of lumped physiological responses to heat stress. The challenge to each of the thermoregulatory models is the accurate prediction of the entire time course of change in body temperature. Part of the study focused on the accuracy of metabolic heat production estimates in the models which impact on accuracy of prediction of the level of body core temperature designated as a heat casualty limit. The analysis showed that accuracy, for example, of predicting a core temperature of 39°C can vary as much as 10-20% at metabolic levels of 200 to 350 watts. At low workloads there may be an underprediction of heat production during unburdened walking. Also during heavy load carriages, metabolic heat increases as a function of time, rather than staying at a steady-state level as many traditional heat strain models predict. Also discovered in this project was that modeling the effects of hypohydration is not wholly driven by changes in the core temperature set-point level per se, but involves greater understanding of the flux in the content of body fluid compartments and their effects on the whole thermoregulatory and cardiovascular effector systems.

12. Heat and evaporative transfer evaluations were done on a wide variety of new technology fabric systems incorporated into the U.S. Saratoga CB protective suit. Utilization of appropriate coefficients derived from the garments were then incorporated into a USARIEM model database. Copper manikin evaluations were conducted to ascertain the effects of windspeed on the thermal insulation and water vapor permeability of the SARATOGA compared to the U.S. BDO over various undergarments and different battle dress uniforms. It was found that at the highest environmental windspeed (5 mph), the thermal insulation with the Saratoga + Desert Weather BDU (≈ 1.85 clo) was some 7% lower than BDO + Desert BDU (1.98 clo). However, the evaporative potential (i_m/clo= 0.38) of the SARATOGA + Desert BDU in the closed, zipped configuration displayed evaporative potential almost 170% greater than the BDO +Desert BDU values (i_m/clo=0.14). It was concluded that the potential use of the SARATOGA technology in chemical protective suits must be coupled with supplementary modeling and experimental analyses at various wind speeds, climates, and work activities.

13. A study was conducted for the U.S. Navy to study the effects of prolonged water contact on thermal insulation of cold weather footwear. Often Navy personnel deployed to polar and sub-polar regions are exposed to a number of occupational and environmental hazards while both ashore and afloat. The standard issue U.S. Navy boot uses wool felt insulation to provide thermal protection sealed within a rubber vapor barrier. However, this boot is heavy; it loses insulating ability if punctured and causes excessive foot skin sweating. This study was requested by U.S. Navy to assist in their further development of an improved Cold Weather Safety Boot (CWSB) that is lightweight, totally waterproof, more breathable and also provides impact protection to the toes. The standard boot (Control) and six commercially available CWSBs were studied on our 29-section thermally isolated, heated, copper foot manekin. The six prototypes were: 1) Ranger "Firewalker," with steel safety toe, having THINSULATE® insulation, and SYMPATEX®, a hydrophilic membrane; 2) Modified Ranger "Firewalker" with fiberglass safety toe, THINSULATE insulation, and SYMPATEX membrane; 3) Chippewa boot (no.79371) with steel safety toe, THINSULATE insulation and fleece lining; 4) Lehigh boot (no.1107) with steel safety toe,

THINSULATE insulation and SYMPATEX, membrane; 5) LaCross "Bison" boot with steel safety toe and removable polypropylene felt inner boot; and 6) Matterhorn boot (no.1949) with steel safety toe, THINSULATE insulation, and GORE-TEX® PTFE membrane. Results showed that the standard issue boot provided the best performance in thermal insulation (smallest overall thermal insulation loss at all sites) and greatest protection against wetting. It was found, however, that three footwear systems (boots 1, 2, and 3 above) that are completely lined with a SYMPATEX® offer an extremely good thermal transfer design potential from which to base a model for a new standard issue item. The use of the monolithic, hydrophilic polyester (SYMPATEX®) membrane permanently bonded to the inner surface of the leather upper of military cold-wet weather footwear was found to significantly reduce regional, and local thermal insulation losses, in tests where footwear was placed in 8 cm of water for 18 h. Increases in boot weight due to water absorption were also significantly smaller with footwear employing SYMPATEX compared to similar boots either with a PTFE membrane or without a membrane. Additional research and model evaluations are necessary in boot thermal transfer systems using this membrane structure for optimization of wearer comfort and tolerance in cold-wet weather. A human biophysical study is also warranted, to validate our copper foot study.

14. The effects on regional connective heat exchange of alternating air flow over the body surface by body posture changes were studied using static copper manikins. Air velocities were measured at six body sites and in two postures; sitting and standing. Large variations were found in the regional air flows but posture-induced differences were less than those calculated by classical free- and forced-convection equations. The free-stream air velocity was found to give a reasonable approximation of the total body mean air velocity. Use of the mean air velocity in the USARIEM Heat Strain Model probably adequately integrates the total wind effect whether the soldier is in sitting position (e.g., silent watch) or standing (e.g., sentry duty). Localized thermal discomfort and changes due to body movement however, are not wholly accounted for by the use of average windspeed. Further human biophysical studies are necessary to develop

prediction equations specifying the effects of regional wind speed, particularly while clothed in BDU + BDOs.

15. A laboratory study was conducted on four samples of the newly fabricated prototype Heat Stress Monitor (HSM) system, consisting of electronic sensor systems which measure (real time) air temperature, dew point, wind speed, and black globe temperature. The study was conducted in the USARIEM Hypobaric Facility (at sea level) in a modified wind box. The HSM has algorithms incorporating basic equations of the USARIEM Heat Strain Model which allow the direct reading of predictions for work/rest cycle limits and hourly drinking water needs. Testing has been completed over ambient conditions spanning hot/wet through hot/dry, at simulated wind speeds to 20MPH. The output of the wind anemometer is the weakest link of the HSM and requires proper adjustment of its coefficient. The output readings almost duplicate those of the standard heat-stress calculator. Following retrofitting of the prototypes with appropriate coefficients to adjust for the anemometer error, the HSM will be evaluated in a field study, pending TDY funding.

16. A human biophysical study was conducted to examine effects of hypobaric environments on heat transfer through chemical protective clothing. The results indicate that a clothing thermal efficiency factor (Burton's F_{cl}), affecting sensible heat loss, becomes elevated at 15,000 ft (P_B= 428 Torr). The effect appears to hold for both BDU and BDO, in MOPP 1 thru 4 configurations.

<u>PUBLICATIONS</u>:

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2. Chang, S.KW. and R.R. Gonzalez. Characteristics of a heat transfer coefficient derived from application of heat-mass transfer analogy on sublimating naphthalene disk data. In: J.A.Reizes, (Ed.) <u>Transport Phenomena in Heat and Mass Transfer</u>. Elsevier: Australia, 1992., <u>Vol 1</u> pp. 396-407.

3. Chang, S.KW. and R.R. Gonzalez. Clothing insulation prediction in hypobaric environments. In: McBriarty, J.P. and N.W. Henry (eds.) Performance of Protective Clothing:Fourth Volume, ASTM STP 1133, American Society for Testing and Materials, Philadelphia, PA, pp. 604-615, 1992.

4. Chang, S.KW. Body postures, air velocity variations, and thermal comfort. In: Advances in Industrial Ergonomics and Safety IV. S.Kumar (Ed). Washington, DC: Taylor and Francis, pp. 615-622, 1992.

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6. Endrusick, T.L., W.R. Santee, W.R., DiRaimo, L.A. Blanchard, and R.R. Gonzalez. Physiological responses while wearing protective footwear in a cold-wet environment. In: Performance of Protective Clothing:Fourth Volume, ASTM STP 1133, McBriarty, J.P. and N.W. Henry (eds.), American Society for Testing and Materials, Philadelphia, PA, pp. 544-556, 1992.

7. Gonzalez, R.R., W.R. Santee and T.L. Endrusick. Physiological and biophysical properties of a semipermeable attached hood to a chemical protective garment. In: Performance of Protective Clothing:Fourth Volume, ASTM STP 1133. McBriarty, J.P and N.W. Henry (eds.), American Society for Testing and Materials, Philadelphia, PA, pp. 557-582, 1992.

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J.P. and N.W. Henry (eds.), American Society for Testing and Materials, Philadelphia, PA, pp. 507-514, 1992.

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11. Santee, W.R. and W.T. Matthew. USARIEM studies soldier's heat strain. U.S. Army Medical Research and Development Command News, pp. 9-10, November, 1992.

12. Santee, W.R., W.T. Matthew and W.J. Tharion. Simulated Approach Marches During Thermal Stress: A P^2NBC^2 Study. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report No. T12-92, 1992.

ABSTRACTS:

13. Chang, S.KW. Human body convective heat transfer determination employing naphthalene disks. FASEB Journal, 6:A2015, 1992.

14. DiRaimo, D.A., W.R. Santee and R.R. Gonzalez. Evaluation of three methods for testing cold weather combat boot systems. Aviation, Space and Environmental Medicine, 63:396, 1992.

15. Toyota, D.A. and L.A. Blanchard. Evaluation of a core temperature telemetry system during exercise/rest cycles. The Physiologist, 35:175, 1992.

PRESENTATIONS:

16. Gonzalez, R.R. Thermal biophysics of the indoor environment, U.California, Berkeley, seminar, 10 April 1992.

17. Matthew, W. Weather effects on the soldier system: Heat stress. Third Workshop on Battlefield Intelligence in AirLand Operations, Computing Research Laboratory, Las Cruces, New Mexico, 27 May 1992.

18. Santee, W.R. Biophysical chemical protective (CP) overgarment testing. Thirty-first Annual U.S. Army Operations Research Symposium, Fort Lee, VA, 16-18 November 1992.

KEY BRIEFINGS:

19. Thomas L. Endrusick. Biophysics clothing methods. Chemical CIE RDA Strategy Plan Joint Service Exchange, Natick, MA, 11-12 June 1992.

20. Richard R. Gonzalez, Ph.D. Modeling properties of the U.S. Army Saratoga CB overgarment. Joint Working Group of Tri-Services CB overgarments, Natick, MA, 14 September 1992.

21. Richard R. Gonzalez, Ph.D. Issues/ modeling characteristics of SN-CIE evaluations. AEHA-ARIEM, Natick, MA, 16 April, 1992.

22. Richard R. Gonzalez, Ph.D. Physiology and performance characteristics. The Technical Cooperation Program Meeting (UTP-6), Natick, MA, 22-25 June, 1992.

23. Richard R. Gonzalez, Ph.D. Medical aspects of design equipment and clothing systems. Singapore Scientific Panel, USARIEM, Natick, MA, 8 July 1992.

24. Richard R. Gonzalez, Ph.D. Biophysical,engineering, and modeling limitations related to milestone 0 of an Army Assault Vehicle (AAV) contract proposal, USARIEM, Natick, MA, 13-16, July 1992.

25. William T. Matthew. Soldier as a system. Joint Working Group, U.S. Army Material Systems Analysis Activity (AMSAA), Aberdeen Proving Ground, MD, 25 February, 1992.

26. William T. Matthew. Integrated performance modeling of the soldier system. Joint MRDC/NRDEC Meeting on Integrated Performance Modeling of the Soldier System, Natick, MA, 1-2 September 1992.

27. William R. Santee, Ph.D. Joint Services Lightweight Integrated Suit Technology (JSLIST) physiological evaluation, Natick RD&E Center, Natick, MA, 21 October 92.

SIGNIFICANT TDY:

Clement A. Levell. To attend/participate in a TRADOC System Manager-Soldier sponsored demonstration of a commercial textile vendor, FT Benning, GA, 11 March 1992.

Clement A. Levell. To attend/participate in a JWG on the U.S. Army Saratoga Project, Battelle Laboratory, Columbus, OH, 15-16 April 1992.

William T. Matthew. To attend/participate in the Design Review Meeting for Environmental Heat Stress Monitor. Southwest Research Institute, San Antonio, TX, 30 April 1992.

William T. Matthew. To attend/participate in the Medical Mission Area Material Plan Conference, Hagerstown, MD, 9-11 June 1992

William T. Matthew. To attend/participate in the Technical Base Executive Steering Committee (TBESC) Soldier System Modeling Working Group Meeting. Institute for Defense Analysis (IDA), Alexandria, VA, 23-24 November 1992.

William R. Santee, Ph.D. To attend/participate in the NATO RSG 20/Panel 8 meeting on cold modeling aspects, Grenoble, France, 4-8 May 1992.

William R. Santee, Ph.D. To perform site visit to SBIR contractor for a heat stress measuring device, Veritay Technology, Inc., Amherst, NY, 22 July 1992.

William R. Santee, Ph.D. To attend/participate in the Army Operational Research (AOR) Conference, FT Lee, VA, 16-19 November 1992.

MAJ Matthew J. Reardon. To participate in training exercises and obtain heat stress data at the National Training Center (NTC), FT Irwin, CA, 4-23 August 1992.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Gonzalez, Richard R., Ph.D., Division Chief. Adjunct Professor of Environmental Science and Physiology, Harvard

School of Public Health, Boston, MA; Technical Consultant and Pre-Doctoral Student Advisor: University of North Texas, Computer Sciences Department; Advisor, National Academy of Sciences/National Research Council Research Associateship Program; Member, U.S. Army Joint Service Lightweight Integrated Suit Technology (JSLIST) Materials Evaluation Working Group; Member, NATO Research Study Group (RSG) 20, Panel VIII, "Modeling in Cold Environments", Brussels, Belgium; Intersociety Representative to the International Standards Organization (ISO) Technical Committee 59 "Ergonomics"; Federation of American Societies for Experimental Biologists (FASEB), Washington, D.C., Minority Schools Lecturer Roster; American Society of Heating, Refrigeration, Air-conditioning Engineers, Member, U.S. Standards Committee on Indoor Thermal Occupancy (55-81R); Technical Corresponding Consultant, Thermodynamics and Psychrometrics Committee (TC 1.1); Physiology and the Human Environment Committee (TC 2.1). Reviewer: Science, American Journal of Physiology: Modeling in Physiology;Journal of Applied Physiology;J.Thermal Biology; American Society of Heating Refrigeration Engineers; Aviation, Space, and Environmental Medicine.

Matthew, William T. Member, Integrated Logistical Support Management Team for Army Environmental Heat Stress Monitor; Member Soldier System Architecture Working Group; USARIEM representative, Technical Base Executive Steering Committee (TBESC) Soldier System Modeling Working Group; Participant, Technical training program for Terrascan satellite data/image processing software package.

Santee, William R. Ph.D. Reviewer: NATO grant proposals; American Society for Testing and Materials.

Endrusick, Thomas L. USARIEM member of Joint Service Lightweight Integrated Suit Technology (JSLIST) Materials Evaluation Working Group.

Levell, Clement A. USARIEM member of Joint Service Lightweight Integrated Suit Technology (JSLIST) Materials Evaluation Working Group.

THERMAL PHYSIOLOGY & MEDICINE DIVISION

SIGNIFICANT RESEARCH FINDINGS/ACCOMPLISHMENTS:

1. The purpose of this study was to examine the influence of exercise intensity and clothing level on body core temperature at exhaustion from heat strain. Seven male soldiers (mean±SD age, 21±3 yr; $\dot{V}o_2max$, 52±6 $ml \cdot kg^{-1} \cdot min^{-1}$, body weight, 80±11 kg) attempted three treadmill walks in a hot environment (43°C db, 20% rh); at a metabolic intensity of 622±61 W wearing protective clothing (pants and top) with (F; clo = 2.0) and without (P; clo = 1.8) mask, hood and gloves, and at 430±42 W (M) dressed in F. Twenty of 21 experiments ended due to exhaustion from heat strain. The mean (±SD) rectal temperature (T_{re}) at exhaustion was not altered by exercise intensity (H-F= 38.4±0.5°C and M-F= 38.6±0.4°C), but was higher during H-P (39.0±0.5°C; $P < 0.05$) than H-F. Cumulative frequency distributions indicated that 25%, 50% and 75% of the subjects were heat casualties at T_{re} of 38.1, 38.6 and 38.9°C during M-F; 38.1, 38.5 and 38.7°C during H-F; and 38.6, 38.8 and 39.3°C during H-P, respectively. Mean skin temperature at exhaustion was similar during M-F and H-F (37.3±0.5 vs 37.4±0.5°C) and higher compared to H-P (36.9±0.6°C; $P < 0.05$). Conclusions: (1) exercise intensity does not alter the rectal temperature at which exhaustion from heat strain occurs, (2) slightly improved heat loss capabilities increase one's tolerance to heat strain, suggesting the importance of skin temperature on tolerance to heat strain, and (3) curves can be developed to predict the incidence of exhaustion from heat strain at a given core temperature.

2. The purpose of this study is to examine the interaction of hydration and exercise intensity on the thermoregulatory and cardiovascular responses during exercise. The experiment consists of nine experimental trials during which subjects exercise for 50 min in a warm environment (30°C db, 50% rh). During each trial, subjects exercise at one of three exercise intensities (25%, 45% and 65% maximal oxygen uptake) at one of three levels of hydration (0%, -3% and -6% of body weight induced by prior exercise-fluid restriction). Esophageal, rectal and skin temperature, as well as local sweat rate are recorded at one-minute intervals during exercise. Cardiac

output is determined after 10 and 35 min of exercise. Blood samples to determine blood volume, osmolality, sodium concentration, and fluid regulatory hormone concentrations are taken prior to exercise, at 20 and at end of exercise. To date, five subjects have completed the protocol. An additional five subjects are scheduled to be tested during January - May, 1993.

3. We compared thermal strain in soldiers exercising at equivalent protective levels of SIPE and standard Mission Oriented Protective Posture (MOPP) clothing. Eight men attempted seven trials of 100-min treadmill walking (450-570 watts) in a 30°C, 50% rh climate. Comparisons were MOPP 0 vs SIPE 0; MOPP 1 vs SIPE 1; MOPP 4 vs SIPE 4 NC (no cooling) vs SIPE 4 MCC (ambient air microclimate cooling). Endurance time (ET), rectal temperature (T_{re}), mean skin temperature ($\bar{T}_{sk}$), heart rate (HR), evaporative sweating (E_{tot}) and heat storage (S) were determined. There were no differences in the experiments between MOPP 0 vs SIPE 0 or MOPP 1 vs SIPE 1. ET (min) was less in SIPE 4 NC (64±11) than in either SIPE MCC (93±7) or MOPP 4 (86±9), and this difference was due to non-thermal factors. $\bar{T}_{sk}$ (°C) was less in SIPE 4 MCC (35.7±0.7) than in either SIPE 4 NC (36.8±0.4) or MOPP 4 (36.6±0.4). E_{tot} ($W \cdot m^{-2}$) was greater in SIPE 4 MCC (201±17) than in either SIPE 4 NC (143±25) or MOPP 4 (167±20). S ($W \cdot m^{-2}$) was less in SIPE 4 MCC (44±11) than in either SIPE 4 NC (66±12) or MOPP 4 (68±13). HR ($b \cdot min^{-1}$) was less in SIPE 4 MCC (145±12) than in either SIPE 4 NC (159±15) or MOPP 4 (161±19). SIPE clothing did not cause greater thermal strain than equivalent MOPP levels; and ambient air MCC reduced thermal strain in this environment.

4. Thermoregulatory responses were compared for 10 soldiers in the laboratory and 13 in the field, while they wore the Battle Dress Overgarment (BDO) or the Chemical Protective Undergarment (CPU). In the laboratory the garments were compared in three environments, 32° C/50% rh, 38° C/30% rh, and 24°C/80% rh. The chemical protective garments were worn in Mission Oriented Protective Posture (MOPP) levels 2 and 4, during rest and treadmill walking, for up to three hours. In general, when the protective clothing was worn with a duty uniform, Desert Battle Dress Uniform (DBDU) or Combat Vehicle Crewman Coverall (CVC) with body armor, heart rate and

temperature responses were attenuated and evaporative sweating rates were enhanced when the volunteers wore the CPU. When the BDO was worn over personal underwear only (U), responses were similar to those of the CPU tests (all tests with CPU worn under duty uniform). In the field at Yuma Proving Ground, in Arizona in July (~34°C/20% rh), the volunteers each tested on two days, one day wearing the CPU+DBDU, and one day wearing the BDO+U (MOPP 1). The volunteers alternated 30 min-walks on a packed sandy road, with 15-min rests, for up to 3.5 hours. As seen during the laboratory testing, responses between CPU and BDO were similar.

5. This study examined whether thermoregulatory adaptations accompanying improved aerobic fitness could occur independently of ambient thermal conditions during training. Nine men trained 8-wks (1-hr cycling at 60% $\dot{V}o_2max$, 5d/wk) in cold water (20°C, CWT) while nine others (matched for $\dot{V}o_2max$ and body composition) trained in hot (35°C, HWT) water. Before and after training, each man performed 60-min exercise ($\dot{V}o_2 = 2.01 \pm 0.04$ L/min) in cold and, on a separate day, in hot water. Rectal, skin and vastus lateralis temperatures (T_{re}, T_{sk}, T_m) were compared. Training increased $\dot{V}o_2max$ 13% ($P<0.01$) in both groups, but had no effect on % body fat of either group. For both CWT and HWT, the fall in T_{sk} during exercise in cold water was faster after training than before ($P<0.01$), however, by 30 min of exercise, T_{sk} plateaued at the same level as before training. Training had no effect on T_{sk} during exercise in hot water. Training had no effect on post-exercise T_m in hot or cold water. Both before and after training, T_{re} and T_m of CWT and HWT rose higher ($P<0.01$) during exercise in hot water. Both groups exhibited lower ($P<0.01$) T_{re} during exercise following training, regardless of the water temperature. We conclude that improved aerobic fitness with endurance training, independent of thermal stress: 1) results in a faster vasoconstriction during exercise in cold water; and 2) results in maintenance of lower core temperature during exercise in hot water as well as cold water.

6. This study examined how two core temperature telemetry pill systems (Konigsberg Instruments, KI (T_{ki}) and Human Technologies, HTI (T_{hti})) compared to esophageal temperature (T_{es}) and rectal temperature (T_{re}) during exercise/rest cycles. Two hours after swallowing both pills, eight volunteers

exercised on a cycle ergometer (T_a=29°C, T_{dp}= 11°C) for 40 min at 40% peak $\dot{V}O_2$, rested 15 min, then completed 3 cycles of 5 min of exercise at 80% peak $\dot{V}O_2$ and 5 min of rest. T_{es}, T_{re}, T_{ki} and T_{hti} were recorded every 30 s. T_{es} (17.8±8.1 min), T_{ki} (17.8±8.4 min) and T_{hti} (22.5±9.9 min) were judged to be at steady state faster during moderate exercise ($p \le 0.001$) than T_{re} (35.7±5.3 min). The change in T_{re} with change in activity (rest/exercise/recovery) was significantly less than the change in T_{es}, T_{ki} and T_{hti} ($p \le 0.001$). However, the mean change in core temperature during steady-state moderate exercise was not significantly different (p=0.12) among the four core temperature indices. The change in core temperature per time (slope) was greater for T_{es} (0.073±0.037°C·min^{-1}) than T_{ki} (0.039±0.023°C·min^{-1}) and T_{re} (0.018±0.005°C·min^{-1}). In addition, this slope was greater for T_{hti} (0.049±0.029°C·min^{-1}) than T_{re}. However, the T_{ki} slopes were not different from T_{re} slopes. The total change in core temperature (peak - rest) was larger ($p \le 0.01$) for T_{es} (0.93±0.21°C) and T_{hti} (0.90±0.24°C) than T_{ki} (0.63±0.25°C). The change in T_{ki} was not different from T_{re} (0.76±0.25°C). The majority of the T_{ki} data indicates that it does not respond as fast as T_{es}, but responds just as quickly as T_{re}. T_{ki}, during a 1.0°C change in core temperature lagged by nearly 0.4°C. The concept of using a temperature sensor in a pill may be useful clinically, but mobility of the pill makes this temperature measurement less suitable for research than esophageal or rectal temperature measurements.

7. A physically fit, premenopausal woman exercised at 60% peak $\dot{V}O_2$ at T_a=30°C, T_{dp}=12°C during adjuvant therapy (days 0,16,70,147) for breast cancer (CA, infiltrating and intraductal carcinoma). Adjuvant therapy consisted of i.v. cyclophosphamide (Cytoxan®, 600 mg·m^{-2}; Bristol-Myers Oncology), methotrexate sodium (40 mg·m^{-2}; Astra Pharmaceutical) and 5-fluorouracil (600 mg·m^{-2}; Roche Laboratories) administered once every 21 d for six months (CMF). Anti-emetic therapy (Compazine®, 10 mg; SmithKline Beecham Pharmaceuticals) and i.v. dexamethasone sodium phosphate (Decadron®, 20 mg·m^{-2}; Merck, Sharp & Dohme) were administered before the anti-neoplastic drugs. During the 3rd CMF, the serotonergic inhibitor, ondansetron hydrochloride (Zofran® 10 mg; Glaxo Pharmaceuticals) was administered after Decadron®. Forearm blood flow (FBF), sweating rate ($\dot{m}_s$) and esophageal temperature (T_{es}) were measured during exercise in

the follicular phase of the menstrual cycle. The T_{es} thresholds for $\dot{m}_s$ and FBF were shifted rightward during CMF (from 36.58°C and 36.75°C to 37.20°C and 37.21°C, respectively) after the first treatment. The T_{es} thresholds remained elevated throughout CMF. By 64 days after CMF, the T_{es} thresholds for $\dot{m}_s$ and FBF returned toward day 0 (36.66°C and 37.01°C, respectively). During adjuvant therapy for CA, FBF and $\dot{m}_s$ s responded appropriately to increased internal temperature. However, the onset of these thermoregulatory effectors was shifted toward a higher internal temperature. These data indicate that CMF altered the thermoregulatory set point, but did not impair thermoregulatory effector function.

8. An in-depth review was conducted on thermoregulation in women with normal menstrual function, including the impact of the menstrual cycle on fluid volume regulation during exercise, heat or cold stress. Also, the impact of menstrual dysfunction, pregnancy and menopause on thermoregulation are reviewed. Suggestions for future research and essential considerations for research design of thermoregulatory studies of women were made. Thermoregulation in women of reproductive age is characterized by an increased core temperature threshold for onset of all thermoregulatory effectors during exercise, heat exposure and cold exposure during the luteal phase of the menstrual cycle. Higher core temperature thresholds for onset of thermoregulatory effector function is consistent with increased set-point temperature ($\uparrow T_{set}$) in the luteal phase. Thermoregulation may be compromised during prolonged exercise or heat exposure in the luteal phase, perhaps due to the smaller plasma volume during that phase. Postmenopausal women have the same sweating to increased core temperature during heat exposure as premenopausal women have. Premenopausal and postmenopausal women have lower resting core temperature and core temperature thresholds for onset of sweating and cutaneous vasodilation during exercise after estrogen replacement therapy (ERT) than they did before therapy. Thus, ERT may be associated with $\downarrow T_{set}$.

9. The effect of increased skin blood flow (SkBF) after nicotinic acid ingestion (niacin, 5 mg·kg^{-1}) was studied in four subjects at rest and during moderate exercise (50% $\dot{V}o_2$ peak, T_a = 29°C, T_{dp} = 10°C, rh =30%). Each subject did four experiments: 1) at rest after nicotinic acid (NR), 2) a

control experiment at rest (CR), 3) thirty minutes of exercise 20 min after niacin ingestion (NX), and 4) a control exercise experiment (CX). Esophageal (T_{es}) and mean skin ($\overline{T}_{sk}$) temperatures, SkBF, forearm blood flow (FBF), heart rate (HR) and mean arterial blood pressure (MAP) were measured. Peak SkBF and FBF were 600% higher in NR compared to CR ($p<0.05$). T_{es} was 0.6°C lower and $\overline{T}_{sk}$ was 0.6°C higher at peak SkBF in NR than CR ($p<0.05$). MAP was 12 Torr lower and HR was 14 $b\cdot min^{-1}$ higher at peak SkBF in NR than CR ($p<0.05$). During exercise, SkBF and FBF were 30% higher and T_{es} was 0.3°C lower in NX than CX ($p<0.05$). $\overline{T}_{sk}$, HR or MAP were unchanged between NX and CX. Sweating was lower in NX than CX (6.9 vs 17.4 $g\cdot min^{-1}$, $p<0.05$). SkBF and FBF were not different between NR and NX. The ingestion of nicotinic acid increased skin blood flow at rest and changed core temperature, skin temperature, heart rate and arterial blood pressure accordingly. Nicotinic acid before semi-upright ergometric exercise increased skin blood flow and decreased heat storage during exercise without significant cardiovascular changes. Exercise did not alter the vasodilation observed after niacin ingestion at rest.

10. Medical regulations for minimizing the incidence of exertional heat illness have required reduced exercise levels, increased water consumption, and reduced work; rest cycles only when the wet-bulb black-globe temperature index (WBGT) exceeds 80° F, based on the stress of marching in full gear (1980 TB Med). To determine how appropriate such regulations are, a complete case series of exertional heat illness (EHI) was collected for 216,616 Marine recruits in basic training at Parris Island, SC, during 1982-1991, by reviewing records of all hospitalizations, clinic visits, heat illness surveillance reports, and hourly records of WBGT. There were 1450 cases of EHI. Seventy-five percent of cases occurred between 7-9 AM, at the coolest time of the day, and after running 1-5 miles. EHI case rates were not strongly related to the WBGT level at the time when illness occurred, but were closely related to the maximum WBGT the day before illness. The baseline was 0.5 cases/100,000 person-days for max. WBGT < 60° F. Case rates were 1, 2, 7, 10, 16, 17, and 21.3/100,000 for WBGT intervals of 65-<70, 70-<75, 75-<80, 80-<85, 85-<88, 88-<90, and >90° F, respectively. Hospitalization rates showed a similar relationship. Thus, current regulations need to be improved to reduce the high rates of exertional heat illness which

result from effects of hot weather exposure the day before heavy exercise.

11. Conventional clinical opinion, embodied in medical textbooks, determines that heat stroke does not occur without a body temperature of at least 105 to 106° F. However, our experience suggested that the definitive mental signs of heat stroke (delirium, obtundation, and coma) were often dissociated from high fever when patients were seen and treated within 5-10 min of onset. To test the merit of high fever as a diagnostic criterion, we classified 468 consecutive cases of exertional heat illness at Parris Island, SC, during 1989-1991 into four levels: those who needed no follow-up (level 1); those with brief confusion or amnesia, and needed a follow-up visit (level 2); those with disorientation or prolonged presence of milder signs, and who might be hospitalized (level 3); and those who required immediate hospitalization (heat stroke, level 4). The correlation between peak fever and level of CNS involvement was poor (R^2 = 0.2). As a criterion to diagnose exertional heat stroke, the sensitivity of fever of ≥105° F was only 65% 45/69 cases, the specificity was 82% (328/399 cases), and the positive predictive value was only 39% (45/116 cases). This criterion thus excluded 35% of cases presented with the neurological signs of heat stroke and falsely predicted heat stroke for the 61% of patients with a temperature ≥105° F who did not develop these signs. The diagnosis of heat stroke should be based on the clinical signs of mental dysfunction, without undue reliance on peak body temperature as a guide to severity.

12. During 1988-1990 in reviewing the basic trainees at the Parris Island Marine Corps Recruit Depot, we collected physical performance data on 212 cases of heat illness in male recruits and 887 non-cases (controls) selected from the same training platoons. We evaluated data on height, weight, and physical fitness testing (PFT). The parameters measured on the PFT include pullups, situps, and run times (for 1½ or 3 miles). The height and weight were combined into a body-mass index ($BMI=wt/ht^2$). The means and distributions of each variable were compared in cases and controls, and all variables were entered into stepwise multivariate regression models. The most predictive variables in the regression models were run time (RT1) on the 1½-mile run and the body

mass index conducted during the first week after arrival at Parris Island. The total PFT score (SC2) during the second test (conducted about three weeks into training) was also somewhat predictive, being a summary of the pullups, situps, and run time on a three-mile run. Each of these variables was parsed into quartiles, based on its distribution in the control group. Comparing high to low quartiles, recruits in the slowest quartile by run time had a three-fold increase ($p<10^{-5}$) in risk of heat illness compared with recruits in the fastest quartile; and fat recruits (those in the highest quartile for BMI) had more than a three-fold increase ($p<10^{-5}$) in risk of heat illness compared with thin recruits (those in the lowest quartile for BMI). Recruits who were both fat and slow were at seven times the risk of heat illness as those who were thin and fast.

13. The renal, hormonal, and body fluid responses to hyperhydration were studied in 11 male soldiers ($\bar{X}$ age=26.3±1.5 yrs). During hyperhydration trials, subjects ingested one of two experimental solutions followed by the ingestion of a large bolus of water. The total volume of ingested fluid was calculated as a percentage of the subjects's total body water (TBW) as determined by stable isotope (deuterium oxide). The experimental solutions (5.0 $ml \cdot l^{-1}$ TBW) were matched for color and taste, and differed only in that one contained 1.5 $g \cdot l^{-1}$ TBW glycerol. The total volume of experimental solution plus the bolus of water equaled 37 $ml \cdot l^{-1}$ TBW ($\bar{X}$=1765 ± 162 mls). Nine of the 11 subjects also completed a control trial during which no fluid was ingested. Compared to the water trial, glycerol ingestion caused significantly greater fluid retention (60% vs 32% at 3 hrs post hyperhydration, $p<0.01$) resulting from significantly lower urine flow rates (peak 10.46 vs 6.20 $ml \cdot min^{-1}$, $p<0.01$). Differences in urine flow rates were accounted for entirely by differences in free water clearance (peak 1.16 vs. 8.16 $ml \cdot min^{-1}$ $p<0.01$). Despite differences in the amount of fluid retained, increases in both blood and plasma volume (radioactive chromium and albumin respectively) were similar between hyperhydration trials. Hormonal analyses indicated no effect of either hyperhydration trial on plasma atrial natriuretic peptide concentrations, while plasma aldosterone levels were somewhat, but similarly reduced during both hyperhydration trails. The large differences in free water

excretion between experimental trials would suggest that differences in plasma vasopressin (ADH) concentrations may be involved with the relative fluid conservation during the glycerol trial. In fact, while plasma vasopressin concentrations were significantly reduced during both hyperhydration trials, they tended ($p=0.08$) to be reduced more during the water trial than during the glycerol trial. The relationship between the time course of changes in plasma vasopressin and the time course of changes in urine flow and free water clearance also suggests a vasopressin-mediated mechanism.

14. This study characterized the influence of body fat on thermal, cardiovascular and fluid responses to cold exposure (4 h rest at 15°C, 30% rh wearing shorts and sneakers). Healthy males were grouped on body composition (hydrostatic weighing) with GP#1 (N=3) leaner than GP#2 (N=4) ($P<0.05$; $\bar{X}$ = 9 vs 21%), while lean body mass was similar (65 vs 64 kg). During cold exposure, metabolic rate increased by a similar magnitude in both groups ($P<0.05$; 96 to 175 W) while mean body temperature decreased similarly for both groups ($P<0.05$; 35.0 to 33.0°C). Cardiac output increased in both groups ($P<0.05$; 3.9 to 5.9 $L \cdot min^{-1}$) and again the magnitude of change was similar. Mean arterial pressure remained constant throughout cold exposure and values were not different between groups (89 mmHg). Total peripheral resistance decreased ($P<0.05$; 0.023 to 0.017 $mmHg \cdot ml^{-1} \cdot min^{-1}$) during cold exposure and was similar for both groups. Although urine losses were equivalent (207 and 225 ml), plasma volume (^{125}I) losses were greater in GP#1 than in GP#2 (-15 vs -9% relative change; 467 vs 299 ml absolute change; $P<0.05$). Conclusion: These data suggest that adiposity has little effect on either cardiovascular or thermal responses to resting cold exposure. However, lean subjects may have a greater cutaneous venoconstriction which would reduce pre- to post-capillary resistance and cause a greater plasma efflux during cold exposure.

15. This project evaluated the influence of exercise intensity on heat balance of men and women during cold water immersion. Eight men and eight women were studied during rest or low, moderate and high intensity exercise in cool and cold water. Women are known to be less able than men to defend core temperature (T_{re}) while resting in cold water, despite

thicker subcutaneous fat, due to their larger surface area relative to body mass than men, which facilitates heat loss. This study confirms this observation. Consistent with previous reports, the increased metabolic heat production exhibited by the men during light intensity exercise in cool and cold water was offset by increased conductive and convective heat loss resulting from increased muscle blood flow and limb movement occurring with the transition from rest to exercise. Thus, light intensity exercise did not ameliorate T_{re} declines compared to during rest. The data from this study extend this observation to women; as with rest, women were unable to defend body temperature as well as men during light intensity exercise in cool and cold water despite greater subcutaneous fat thickness. It is known that the transition from light to moderate and higher intensities of exercise, and the increase in metabolic heat production is greater than the increases in conductive/convective heat loss. This study confirms this since the fall in the men's T_{re} was less during moderate and high-intensity exercise compared to rest or light-intensity exercise. This study demonstrated a similar effect in women. In fact, during high-intensity exercise in cold water, women defended T_{re} better than men, reflecting increased conductive/convective heat loss in the men due to perfusion of a larger muscle mass in limbs having less subcutaneous fat compared to women.

16. This study attempted to identify and validate predictors and/or indices of dehydration by utilizing changes in total body water (deuterium oxide) as the gold standard. Twenty-four Marines were studied during a 7-day cold-weather (1-3°C) training exercise. Training consisted of approximately 12 hr/d skiing, hiking, and mountaineering tasks, often with heavy loads. Periodic measurements made over the 7-day period immediately upon awakening included: body weight (Bwt) and composition (%Fat), urine specific gravity (SG), plasma and urinary electrolytes (K^+,Na^+), plasma proteins (PP), plasma and urinary osmolality (P_{OSM}, U_{OSM}), hematocrit (Hct), plasma aldosterone, and total body water (TBW). Significant ($p<0.05$) decreases over the 7-day period were observed in Bwt (1.9 kg), %Fat (0.8%), and TBW (0.9 L), while significant increases were found in PP and plasma K^+ concentrations. While urine specific gravity is often used to monitor hydration status in the field, significant correlations were not found between

changes in TBW to SG, nor between change in TBW to other clinical indicators of dehydration, e.g., U_{OSM}, P_{OSM}, Hct, PP. In fact, the best predictor of changes in total body water, in this study, was in particular, the change in body weight, lean Bwt ($r=0.73$, $p<0.001$). These data suggest that during military field operations, when energy balance, sleep status, circadian rhythms, etc., are altered, standard clinical indices of dehydration may be of little benefit in determining the presence or magnitude of dehydration.

17. To establish an epidemiological baseline for the study of disease and injury trends in soldiers at Arctic Latitudes, a retrospective cohort survey study was performed on four company sized units within the 6th Infantry Division's Brigade at Fort Wainwright, Alaska. Existing data, from medical and dental records, unit records, training records, Army Physical Fitness Test (APFT) score cards, and meteorological records, were utilized to examine to association of health outcomes (illness, injury, behavior) with intrinsic factors (demographic and physical characteristics), and extrinsic factors (occupation and environmental factors). A questionnaire was utilized to capture more detailed information on demographics, family background, personal habits, experience and attitude towards the cold. The primary objectives of this study were to: 1) document the incidence and types of illness and injuries in general, and cold injuries in particular, occurring in soldiers stationed at arctic latitude, and 2) contrast this with data previously gathered from other arctic and temperate zone latitudes. Data are currently being analyzed to determine trends and factors which may be amenable to preventive intervention.

18. Despite the feeling of warmth induced by alcohol ingestion, it is widely believed that alcohol actually causes a decrease in body core temperature and increases the risk of hypothermia during cold exposure. However, the literature on the effects of alcohol ingestion on thermoregulation is conflicting. This review summarizes the scientific findings concerning this topic and identifies a number of confounding factors that may explain the conflicting observations. These factors include: quantity of alcohol ingested, severity of cold, nutritional state of the individual, composition of the drink, body composition of the individual, and alcohol

tolerance of the individual. When these factors are considered, it appears that: 1) alcohol does cause a reduction in body core temperature, with the magnitude of reduction related to blood alcohol concentration; 2) the severity of cold and the individual's body composition modify the thermoregulatory effects of alcohol; and 3) hypoglycemia greatly exacerbates the reduction in body temperature caused by alcohol ingestion. Furthermore, the literature suggests that the mechanism by which alcohol ingestion exacerbates the fall in body core temperature during cold exposure is by impairing metabolic heat production, rather than increasing heat dissipation via vasodilation, as commonly believed.

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repeated exercise-heat stress. Proceedings of 1991 Bioscience Review, 1992.

PRESENTATIONS:

32. Curtis, W., R. Francesconi, P. Szlyk, L. Armstrong, R. Hubbard, N. Leva, R. Moore, W. Matthew and E.W. Askew. Heat acclimation: Effects on blood pressure during rest and exercise. Seventh Annual Conference on Military Medicine: Military Medical Conference on Medical Aspects of Operation Desert Storm/Shield. Bethesda, MD, April 1992.

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35. Sawka, M.N. Physiological and medical problems associated with heat, cold and altitude environments. Massachusetts General Hospital, Boston, MA, February 1992.

36. Sawka, M.N. Human thermoregulation during exercise-heat exposure. Southern Illinois University, Carbondale, IL, May 1992.

37. Sawka, M.N. Chemical warfare protective clothing: Thermoregulatory problems and solutions. Symposium on The Challenge of Exercise Wearing Biological Chemical Warfare Protective Clothing. American College of Sports Medicine Annual Meeting, Dallas, TX, May 1992.

38. Sawka, M.N. Fluid control and temperature regulation in the heat. Boston University, Boston, MA, October 1992.

39. Sawka, M.N. Cardiovascular responses and control during exercise. Massachusetts General Hospital, Boston, MA, November 1992.

40. Young, A.J. Effects of repeated cold exposure and physical training on thermoregulatory responses to cold. Invited presentation in the Symposium on Understanding Thermal Balance in the Cold, Second Annual Wilderness Medicine Conference, sponsored by the Wilderness Medical Society, Big Sky, MT, March 1992.

41. Young, A.J. Cardiovascular and thermal effects of water immersion. Symposium on Research and Clinical Application in Swimming, American College of Sports Medicine meeting, Dallas, TX, May 1992.

42. Young, A.J. Acute and chronic effects of cold and high altitude on physiological responses to exercise. Boston University, Boston, MA, October 1992.

KEY BRIEFINGS:

43. Beau J. Freund, Ph.D., MAJ, MS. Oral administration of glycerol solutions to prevent or reduce cold induced dehydration and the associated decrements in work performance: Potential applications during Special Forces Operations. To: COL William Hughes, Command Surgeon, U.S. Special Operations Command, May 1992.

44. Beau J. Freund, Ph.D., MAJ, MS and Scott J. Montain, Ph.D., CPT, MS. Fluid requirements and replacement strategies: What do we know and where do we go? To: personnel from Singapore's Ministry of Defense, July 1992.

45. Sven K. Ljaamo, M.D., MAJ, MC. Area medical study of Russia: Environmental, infectious disease, and personal safety considerations for DoD. To: travelers to St. Petersburg and Moscow. 10th and 11th Special Forces Groups (A), Fort Devens, MA, September 1992.

46. Michael N. Sawka, Ph.D. Physical work performance benefits from microclimate cooling. To Deputy Assistant Secretary for Research and Technology, The Pentagon, Washington, DC, March 1992.

47. Michael N. Sawka, Ph.D. Physical work performance on a chemical battlefield: Thermal problems and solutions. Joint Service Microclimate Cooling Review, Natick, MA, March 1992.

48. Michael N. Sawka, Ph.D. Microclimate cooling: Current status and future directions. U.S. Army Chemical School, Fort McClellan, AL, May 1992.

49. Andrew J. Young, Ph.D. Ergogenic potential of autologous erythrocyte infusion procedure for Special Operations Forces rapidly deployed to high altitudes. To Special Operations Command Surgeon and Staff, U.S. Special Operations Command Headquarters, McDill, AFB, FL, January 1992.

SIGNIFICANT TDY:

Sven K. Ljaamo, M.D., MAJ, MC. To perform field study: "Morbidity Experienced by Non-Indigenous Military Personnel Assigned to Duty at Arctic Latitudes", Fort Wainwright, Alaska, 1-16 March 1992.

Sven K. Ljaamo, M.D., MAJ, MC. To (1) initiate contact with Russian scientists investigating environmental medical issues at terrestrial extremes, and (2) serve as unit medical officer while participating in in-country language training with the 10th and 11th Special Forces Groups (A), St. Petersburg, Russia, 30 September - 31 October 1992.

Sven K. Ljaamo, M.D., MAJ, MC. To make a reciprocal visit to Professor Oleg S. Medvedev, M.D., Dean of the Faculty of Basic Medical Scientists at Moscow State University, and Chairman, Department of Experimental Pharmacology at the Russian Cardiology Center, Moscow, Russia, 1-4 November 1992.

Sven K. Ljaamo, M.D., MAJ, MC. To provide technical consultation on cold injury research to COL Juan Garcia, MC (V Corps Surgeon) and LTC Marc Taylor, MC (Chief, Surgical Service, USAMEDDAC Würzburg), Frankfurt A.M. and Würzburg, Germany, 4-7 November 1992.

C. Bruce Wenger, M.D., Ph.D. To manage the project, "Epidemiological Study of Heat Injury Among Marine Recruits",

with the Uniformed Services University of the Health Sciences. Beaufort, SC, March 1992; November 1992.

Andrew J. Young, Ph.D. To participate in the 32nd meeting of Working Party 61 of the Air Standardization Coordinating Committee, Aviation Medical Unit, RNZAF Base, Auckland, NZ, November 1992.

SIGNIFICANT VISITORS:

James Bagian, M.D., Astronaut, NASA, LBJ Space Center, Houston, TX, presented seminar, 19 May 1992.

COL William Hughes, Command Surgeon, U.S. Special Operations Command, May 1992.

Professor Oleg Stepanovich Medvedev, M.D., Dean of Basic Medical Scientists at Moscow State University, and Chairman, Department of Experimental Pharmacology, Institute of Experimental Cardiology at the Russian Cardiology Center, Moscow, Russia, (while at M.I.T. as a collaborative researcher) 14 August 1992.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Michael N. Sawka, Ph.D., Division Chief. Associate Professor, Institute of Health Professions, Massachusetts General Hospital, Boston, MA; Editorial Board, Aviation, Space and Environmental Medicine; Chair, Project Review Committee, American College of Sports Medicine; Member, Visiting Scientists for Minority Institutions Programs, American Physiological Society; Member, Nuclear/Biological Chemical Protective Equipment Subgroup, Chemical Defense Technical Cooperation Program; Member, Physiological and Psychological Effects of Nuclear, Biological and Chemical and Sustained Operations on Systems in Combat Program (P^2NBC^2; Alumni Achievement Award, Southern Illinois University, 1992. Editorial Board, Journal of Applied Physiology. Reviewer, National Science Foundation; Reviewer, American Journal of Physiology; Aviation, Space and Environmental Medicine, European Journal of Applied Physiology, International Journal of Sports Nutrition; International Journal of Sports Medicine; Journal of Applied Physiology; Medicine and Science in Sports

and Exercise, Perspectives in Exercise Sciences and Sports Medicine; Research Quarterly for Exercise and Sport; Undersea Biomedical Research; The Journal of Cardiorespiratory Rehabilitation.

Beau J. Freund, Ph.D., MAJ, MS. Fellow, American College of Sports Medicine; Chairman, Abstract Reviews, for Fluid and Electrolytes Section, American College of Sports Medicine; Member, Project Review Committee, American College of Sports Medicine. Reviewer, Journal of Applied Physiology; American Journal of Physiology, Medicine and Science in Sports and Exercise.

Margaret A. Kolka, Ph.D. Member, U.S. Army Medical Research and Development Command Steering Committee for Multichambered Autoinjector; Member, USARIEM Scientific Review Committee. Reviewer, European Journal of Applied Physiology; Journal of Applied Physiology; American Journal of Physiology (Reg. Int., Comp. Physiol.; American Journal of Physiology (Heart and Circul.).

Sven K. Ljaamo, M.D., MAJ, MC. Staff Preventive, Occupational, and General Medical Officer, Cutler Army Community Hospital, Fort Devens, MA; Editorial Board, International Medical Reviews.

Scott J. Montain, CPT, MS. Reviewer, Medicine and Science in Sports and Exercise; International Journal of Sports Medicine

Lou A. Stephenson, Ph.D. Reviewer, Journal of Applied Physiology.

C. Bruce Wenger, M.D., Ph.D., Member, Subcommittee C95.1-IV Working Group 11 (Metabolism/Thermoregulation), American National Standards Institute, New York, NY; Reviewer, Journal of Applied Physiology, American Journal of Physiology, Medicine and Science in Sports and Exercise, South African Journal of Science, IEEE Transactions on Biomedical Engineering, Pflügers Archiv/European Journal of Physiology, Canadian Journal of Physiology and Pharmacology, Chest.

Andrew J. Young, Ph.D. U.S. Army Project Officer, Project Group 114, Aeromedical Considerations of Thermal Stress and

Survival, Working Party 61, Air Standardization Coordination Committee. Adjunct Lecturer, Department of Physical Therapy, Institute of Health Professions, Massachusetts General Hospital, Boston, MA. Editorial Board, Medicine and Science in Sports and Exercise; Member, Research Review Committee, American College of Sports Medicine. Reviewer, Medicine and Science in Sports and Exercise; Journal of Applied Physiology; Arctic; Aviation, Space and Environmental Medicine, American Journal of Physiology.

USARIEM
CY92

OCCUPATIONAL HEALTH AND PERFORMANCE DIRECTORATE

RESEARCH FINDINGS: EXECUTIVE SUMMARY

- Demonstrated that a 15% increase in caloric intake above the usual energy-deficient diet during Army Ranger training diminished the severe weight loss and body composition changes but does not normalize the trainee's impaired immunological status.

- An equation which predicts the metabolic cost of locomotion from the ratio between body mass and the amount of time the foot is in contact with the ground, was successfully validated with indirect calorimetry during walking and running on a horizontal treadmill.

- Cigarette smoking was confirmed as an independent risk factor for musculoskeletal injuries in a variety of different aged Army populations.

- Demonstrated that a new prototype sock system (thin inner sock of polyester plus an outer thick sock of wool-polypropylene combination) reduces blister formation when tested during Marine recruit training.

- Preliminary evaluations showed that an outside-the-boot ankle brace worn during parachuting is effective in reducing ankle sprains without increasing the risk for other injuries.

- Demonstrated that muscle wastage due to prolonged energy deficit during Army Ranger training is more pronounced in the upper body than the legs, with the loss in muscle performance being greater than can be accounted for by the loss in muscle mass, implicating neuromuscular and/or metabolic factors.

- Demonstrated that a conservative guideline to the lifting capability of team lifts, would be to expect a 2-person team to lift 1.5 times and a 4-person team to lift 3 times what a single person would lift, with single gender teams being more effective than mixed gender teams.

- Demonstrated that giving tyrosine to rats resulted in a dose-dependent increase in the release of brain norepinephrine and an improvement of performance during cold stress.

- Demonstrated that sleeping in the chemical protective mask (M4) compromised mask fit, disrupted sleep, and impaired psychomotor performance throughout the next day.

- MOPP IV conditions significantly increase the metabolic cost of physical tasks that involve whole-body locomotion but do not affect the cost of stationary tasks.

- Demonstrated that captured speech technology can be used to assess the degradation of affective and cognitive behavior during exercise in hot-dry and hot-humid environments.

- An analysis of prior studies demonstrated that there were no differences in nutrient intake between ethnic/minority groups within the military.

- Field studies of severe physical exertion (heavy load carriage over long distances) confirmed early laboratory studies of eccentric exercise that creatine kinase and decrements in muscle strength serve as potentially useful markers of muscle tissue damage.

- Demonstrated that the sustained, multi-stressor environment of Ranger training degraded the cognitive performance of the candidates.

- Demonstrated that antiperspirants can reduce foot sweating, thereby showing potential for reducing the incidence of foot blisters.

PUBLICATIONS:

1. Vogel, J.A. and K.E. Friedl. Body fat assessment in women-special considerations. Sports Medicine, 13:245-269, 1992.

2. Vogel, J.A. Obesity and its relation to physical fitness in the U.S. Military. Armed Forces & Society, 18:497-513, 1992.

3. Vogel, J.A. and K.E. Friedl. Army data: body composition and physical capacity. In: Body Composition and Physical Performance. National Academy of Science Press, Washington, DC, pp. 89-103, 1992.

4. Vogel, J.A., P.B. Rock, B.H. Jones and G. Havenith. Environmental considerations in exercise testing and training (Chapter 13). In: ACSM Resource Manual Guidelines for Exercise Testing and Training, 2d Edition. Lea and Febiger, Philadelphia, (In Press).

5. Vogel, J.A. and J.F. Patton. Physical fitness and physical training for military performance. Chapter in: Physical Medicine and Rehabilitation (volume in Series of Textbook of Military Medicine. Government Printing Office, Washington, DC, (In Press).

PRESENTATIONS:

6. Vogel, J.A. Evaluation of physical performance. National Academy of Science (Food and Nutrition Board) Workshop on Evaluation of Potential Performance Enhancing Food Components for Operational Rations, Washington, DC, 16 November 1992.

7. Vogel, J.A. Physical fitness research and policy issues. Advance Course, Army War College, Carlisle Barracks, PA, 12 May 1992.

8. Vogel, J.A. Military Occupational Ergonomics (Session Chair). Annual International Industrial Ergonomics and Safety Conference, Denver, CO, 10-13 June 1992.

9. Vogel, J.A. Development of Army occupational physical standards. Testimony before Presidential Commission on Assignment of Women in the Armed Forces, Los Angeles, CA, 7 August 1992.

10. Vogel, J.A. Gender differences in physical exercise capacity. Workshop on Women and Gravitational Tolerance, Presidential Commission on Assignment of Women in the Armed Forces, San Antonio, TX, 14-15 September 1992.

SIGNIFICANT TDY:

James A. Vogel, Ph.D. Chair Fifth Meeting of NATO Panel 8 Research Study Group-17, "Biomedical Aspects of Military Training," Oslo, Norway, 16-20 March 1992.

James A. Vogel, Ph.D. Chair Sixth Meeting of NATO Panel 8 Research Study Group-17, "Biomedical Aspects of Military Training," Utrecht, The Netherlands, 9-13 November 1992.

James A. Vogel, Ph.D. U.S. Army representative to The Technical Cooperative Program (TTCP) UAG-12 meeting on "Performance Enhancement of Elite Military Units," Portsmouth, United Kingdom, 24-26 November 1992.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

James A. Vogel, Ph.D., Research Director. Adjunct Professor, Department of Health Sciences, Boston University. Chairman, NATO Research Study Group-17, "Biomedical Aspects of Military Training." U.S. Army representative to The Technical Cooperative Program, Action Group-12 on "Performance Enhancement of Elite Military Units." Trustee, New England Chapter of American College of Sports Medicine. Associate Editor, Journal of Strength and Conditioning Research. Abstract Review Leader, American College of Sports Medicine.

MILITARY NUTRITION DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

1. Caffeine and Trail Marching at Altitude. A study was designed and conducted to determine if caffeine would enhance the physical performance of soldiers at altitude (Pikes Peak, Colo.). Eight male soldiers from U.S. Army Special Forces

(ages 22 to 35 years old) completed two ascents of a 22 km mountain trail (hiking from 1800 m to 4300 m above sea level) after having resided for 8 and 17 days at the summit (4300 m). Soldiers were asked to refrain from caffeinated foods and beverages for two days prior to each ascent. The composition and timing of the pre-ascent breakfasts were controlled. Ninety minutes after breakfast (one hour prior to ascent) each soldier received either caffeine (4 mg/kg body weight) or placebo in a double-blind, cross-over design. Urine samples were collected prior to each ascent for 1-methylxanthine determination. Perceived exertion, blood oxygen saturation, altitude illness symptomatology, and "split times" were measured at selected points along the trail. None of the variables measured differed between placebo and caffeine ascents. The inability to demonstrate an improvement due to caffeine may have been due to unavoidable, confounding factors such as inclement weather on the second ascent, altitude acclimatization between ascents, and/or lack of compliance with a caffeine-free diet, as well as the small sample size.

2. Ethnic/Minority Nutrition. A retrospective study was conducted to determine differences in nutritional intake due to ethnicity. Two out of every five active duty soldiers in the U.S. Army belong to an ethnic/minority group. Since culture determines food habits that, in turn, establish nutritional intakes and ultimately health, the diversity of cultures within the U.S. Army raises concern about the adequacy of nutritional intakes of these soldiers. Data from 216 soldiers who participated in dining hall nutritional surveys conducted by this Institute between 1986 and 1988 were combined and regrouped (white, black, Hispanic, other, and gender). Mean nutrient intakes were found to be similar among groups, meeting 70 percent or more of the Military Recommended Dietary Allowances (MRDA) for all nutrients. Partitioning the data into selected levels of MRDA showed that some individuals were at higher risk of poor nutrition. Yet these individuals did not cluster within any particular minority group. From the data, it cannot be elucidated if the comparable nutrient intakes among groups were due to the acculturation of these soldiers. Although these data suggest no need for targeted educational programs, the available nutritional database of minority groups and female soldiers is small and fragmentary (23% blacks, 8% Hispanics, 24% females).

A larger database of minority groups and female soldiers in the U.S. Army is needed. A survey will be designed to assess acculturation level and prevalence of food intake problems encountered by minority groups in the U.S. Army.

3. Performance Enhancing Ration Components (PERC). This project has as its goal the enhancement of physical and/or mental performance through nutrition. A workshop was held by the National Academy of Sciences to explore the scientific feasibility of this study. Caffeine, carbohydrate, tyrosine, and choline were selected as high potential candidates to investigate during this project. Initial testing will begin in FY93 with carbohydrate supplements. The Ranger Training Brigade was asked to assist in an effort to test a glucose-electrolyte beverage. A protocol to support this effort was begun and is in the final stages of development. A working group was subsequently formed and met to discuss the PERC project. The working group was composed of scientists from the Food Engineering and Soldier Science Directorates of the U.S. Army Natick Research, Development and Engineering Center and the U.S. Army Research Institute of Environmental Medicine.

4. "Ranger II" (Nutritional and Immunological Assessment of Ranger Students with Increased Caloric Intake). This study was the result of efforts of seven investigators from four major research facilities (U.S. Army Research Institute of Environmental Medicine, Walter Reed Army Institute of Research, U.S. Department of Agriculture, and Pennington Biomedical Research Center). Fifty volunteer Ranger trainees completed the study during their eight-week training period. Changes in body composition, strength, selected blood analyses for nutritional status, cognitive function, and immune responses were determined at baseline and after four, five, six, and eight-weeks of training. A 15-percent increase in caloric intake resulted in less body weight loss (15.6 vs 10.0%) when results for Ranger I are compared to Ranger II. Immune responses, defined by <u>in vitro</u> proliferation, were less severe for Ranger II when compared to Ranger I; however, immune responses continue to be suppressed as a result of the training. Assessment of sleep deprivation showed that the subjects averaged 3.8 hours of sleep per day. Cognitive testing showed a decreased capacity to accomplish complex

tasks. The determination of acceptability and adequacy of the newly improved LLRP was tested during the second half of this study. Survey data showed the LLRP to be an acceptable restricted ration. Conclusions regarding the nutritional adequacy of the ration awaits further data analyses.

5. Nutrient Database Restructure and Development of a DOS/PC-based Nutrient Analysis System to Replace the VAX-based Computer Assisted Nutrient Analysis (CAN) System. Review of the Military Nutrition Division's methods for collecting, storing, analyzing, and presenting nutrient intake data from field studies showed the following deficiencies: first, the methods for managing the nutrient database were antiquated, unreliable, and did not provide for timely data management; second, the VAX-based system was not transportable to a field location and was not as user friendly as would be expected of contemporary software systems; third, a local area network (LAN) is needed to provide more efficient management of the data and to network all the principal users of the total system. A joint committee between the Food Engineering Directorate of the U.S. Army Natick Research, Development and Engineering Center (NRDEC) and the USARIEM Military Nutrition Division was formed to determine ways to reconstruct the military nutrient database. To further streamline the procedures for dropping outliers in the database, a smaller, three-person committee was formed. This committee meets frequently; decides which data points are to be screened out of the database, and forwards documentation of its actions for approval to the larger committee. The MRE nutrient database is now approximately 75 percent complete and the T ration nutrient database is approximately 35 percent complete. The database is being managed by Paradox, a user-friendly commercial database management system. Additional information will be available on the (un)saturated fatty acids and the copper content of the rations in the new military database. Various plans are being considered for writing a new CAN system for DOS/PCs. Services of a consultant were obtained to determine the type and cost of a LAN system to meet our needs. The consultant's results have been reviewed and accepted.

6. Special Operational Forces (SOF) Individual Operational Ration. The purpose of this study will be to determine metabolic variation at rest and during exercise and recovery

in a group of SOF soldiers. The underlying hypothesis is that significant variation between individuals with regard to substrate utilization will indicate different nutritional requirements for optimization of physical performance, particularly during mission deployment. Physical activity and nutrition questionnaires were administered to two Special Operational Forces (SOF) teams. A review of the technical and scientific literature was conducted for anthropometric and performance data on elite Special Forces. Analysis of this data supported the contention that SOF soldiers are a distinct sub-population within the Armed Forces. A proposal, "Assessment of Intra- and Inter-individual Metabolic Variation in Special Operational Forces (SOF) Soldiers," was prepared and submitted to the USARIEM Scientific Review Committee and the Human Use Review Committee.

7. Performance Nutrition. In response to a request by the Commandant, U.S. Marine Corps (USMC), the Military Nutrition Division is developing and pilot testing a sports nutrition program for training environments that demand a high level of physical performance. The program consists of two major components: (1) nutritional menu standards for menu planning and suggested menu modifications for a training table and (2) nutrition education with an emphasis on sports nutrition principles. A feasibility test of a low-fat training table menu was conducted at the USMC Officer Candidate School, Quantico, VA. The 5-day test menu provided 7400 kcal/day with a macronutrient distribution of 65% carbohydrate, 13% protein, and 25% fat. Analysis of the dietary intakes of 162 Officer Candidates subsisting on the training table menu yielded a mean energy intake of 4650 kcal/day with a macronutrient distribution of 60%, 14%, and 26% for carbohydrate, protein, and fat, respectively. These dietary intakes were within the MRDA guidelines as well as sports nutrition guidelines for a training diet. This is the first garrison dining hall study to show mean-fat intakes less than 30% fat. The diets of the students subsisting on the training diet was much better than the diets of the students subsisting on the customary Officer Candidates' menu, which was captured during baseline data collection in August 1990. The mean-energy intakes of the students in the baseline study was 4423 kcal. Their macronutrient distribution was 50.5%, 14%, and 35% carbohydrate, protein, and fat, respectively. Cholesterol

intakes of students subsisting on the training table averaged 502 mg/day, higher than the MRDA guideline of ≤ 300 mg/day, but much lower than cholesterol intakes of the baseline students (693 mg/day). Sports nutrition knowledge questionnaires were administered to 236 Marine recruits. The average score on the sports nutrition knowledge questionnaire was 44%, slightly less than the 51% score of the Marine officer candidates previously determined. These results reaffirm the need for nutrition education of service members starting early in their careers. A contract has been awarded for the development and production of a multimedia sports nutrition education program for pilot testing.

8. Pikes Peak 92, Body Composition. Exposure to high altitude causes alterations in intracellular volume, interstitial volume, and total body water as well as body fat. Standard methods to measure changes in these compartments involve invasive procedures or require equipment that is not easily transported to high altitude field study sites. Multifrequency-bioelectrical impedance is a method that can potentially quantify total body water and extracellular water volumes and predict fat-free mass. In order to validate this technique, multifrequency-impedance measurements were made on 12 males before, during, and after 18 days residence at 4300 meters in conjunction with dual energy x-ray absorptiometry (DEXA) and hydrostatic weighing (HW) estimations of body composition, total body water measurements by deuterium, and extracellular water measurements by sodium bromide. Analysis of the impedance data using manufacturer provided modeling software greatly underestimated fat mass when compared to DEXA or HW. Therefore, multifrequency impedance cannot yet be considered a valid technique for body fat determination. The manufacturer is currently revising their software. Although DEXA and HW estimations of fat and fat free mass (FFM) were highly correlated, they did not yield similar estimations of FFM and fat mass (FM) before or after altitude exposure, nor did they yield the same estimation of relative change in FFM and FM for a given weight loss. The reason for this disparity may be that the DEXA method is more sensitive to body composition changes or is not as affected by hydration status perturbations as is HW. Further analyses of the impedance data is pending provision of the revised software and results of the deuterium and sodium bromide measurements.

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1. Edwards, J.S.A., D.E. Roberts, and S.H. Mutter. Rations for use in a cold environment. Journal of Wilderness Medicine, 3:27-47, 1992.

2. Jones, T.E., S.H. Mutter, J.M. Aylward, J.P. DeLany, R.L. Stephens, D.M. Caretti, D.A. Jezior, B. Cheema, L.S. Lester, E.W. Askew. Nutrition and hydration status of aircrew members consuming the Food Packet, Survival, General Purpose, Improved during a simulated survival scenario. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report No. T1-93, 1992.

3. King, N., S.H. Mutter, D.E. Roberts, E.W. Askew, A.J. Young, T.E. Jones, M.Z. Mays, M.R. Sutherland, J.P. DeLany, B.E. Cheema, and R. Tulley. Nutrition and hydration status of soldiers consuming the 18-man arctic tray pack ration module with either the Meal, Ready-to-Eat or the Long Life Ration Packet during a cold weather field training exercise. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report No. T4-92, 1992.

4. Moore, R.J., K.E. Friedl, T.R. Kramer, L.E. Martinez-Lopez, R.W. Hoyt, R.E. Tulley, J.P. DeLany, E.W. Askew, J.A. Vogel. Changes in soldier nutritional status and immune function during the Ranger training course. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report No. T13-92, 1992.

5. Moore, R.J., K.E. Friedl. Physiology of nutritional supplements: Chromium picolinate and vanadyl sulfate. National Strength and Conditioning Association Journal, 14:47-51, 1992.

6. Salter, C.A. and R.L. Shippee. Dietary Fat. U.S. Army Aviation Digest, Professional Bulletin 1-92-6, pp. 58-61, Nov/Dec 1992.

7. Thomas, C.D., J.C. Peters, G.W. Reed, N.N. Abumrad, M. Sun, and J.O. Hill. Nutrient balance and energy expenditure during ad libitum feeding of high-fat and high-carbohydrate

diets in humans. American Journal of Clinical Nutrition, 55-934-42, 1992.

ABSTRACTS:

8. Baker-Fulco, C.J., J.C. Buchbinder, S.A. Torri, and E.W. Askew. Dietary status of Marine Corps officer candidates. FASEB Journal, 6:A1682, 1992.

9. Kramer, T.R., R.J. Moore, K.E. Friedl, and L.E. Martinez-Lopez. Effects of multiple stressors during U.S. Army Ranger training on cell-immune functions. FASEB Journal, 6:A1215, 1992.

PRESENTATIONS:

10. Askew, Eldon W. Nutrition and Hydration in the Field. Current Concepts in Environmental Medicine, Natick, MA, May 1992.

11. Askew, Eldon W. Work at moderate altitude; how severe is the metabolic stress? Eighth Annual Scientific Meeting of the Wilderness Medical Society, Keystone, CO, September 1992.

12. Baker-Fulco, Carol J. Military nutrition research. Dietary Technician program of Labouré College, Natick MA, October 1992.

13. Baker-Fulco, Carol J. Applications of Food Composition Databases for Military Nutrition Research. Seventeenth National Nutrient Databank Conference, Baltimore, MD, June 1992.

14. Baker-Fulco, Carol J. Military Nutrition research overview. WRAIR/MRDC Fellows annual meeting, Natick, MA, September 1992.

15. Champagne, C.M., D.E. Sherman, C. Baker-Fulco, and J.L. Dean. Comparison of military recipes using computerized nutrient data bases and laboratory values. Seventeenth National Nutrient Databank Conference, June 7-10, 1992.

16. King, Nancy. The Effect of Cold Environment on Energy Expenditure and Nitrogen Balance. Eighth Annual Scientific Meeting of the Wilderness Medical Society, Keystone, CO, September 1992.

17. King, Nancy. Nutrition issues of military women. Thirty-third annual meeting of the American College of Nutrition, San Diego, CA, 11 October 1992.

18. Thomas, Cecilia D. Advanced Course - Fitness of the Army. Army War College, Carlisle Barracks, PA, April 1992.

19. Thomas, Cecilia D. (1) USARIEM AMSC research and (2) Diet Composition Effect on Substrate Oxidation. Mary Lipscomb Hamrick AMSC Research Course, Silver Springs, MD, August 1992.

<u>KEY BRIEFINGS</u>:

20. Eldon W. Askew, COL, MS. Overall USARIEM mission briefed to LTC Lloyd Waterman (Director of Combat Developments, Quartermaster School, Fort Lee, VA), Natick, MA, January 1992.

21. Eldon W. Askew, COL, MS. Occupational Health and Performance Directorate overview. Briefed to Michael A. Stroud, M.D., and Barbara M. Stone (Ministry of Defence, UK), Natick, MA, February 1992.

22. Eldon W. Askew, COL, MS. "Ranger I" study results at Committee on Military Nutrition Research meeting, NAS, Washington, DC, February 1992.

23. Eldon W. Askew, COL, MS. "Ranger I" (Nutritional Assessment Results of Class 11-91 - Background). Briefed to USAMRDC Commander and staff, Fort Detrick, Frederick, MD, February 1992.

24. Eldon W. Askew, COL, MS. Results of "Ranger I" research study and plans for "Ranger II" follow-on study. Briefed to The Surgeon General of the Army and staff and Commander, USAMRDC, Falls Church, VA, March 1992.

25. Eldon W. Askew, COL, MS. Army Nutrition Planning Committee meeting on Military Nutrition Research at USARIEM, Natick, MA, March 1992.

26. Eldon W. Askew, COL, MS. Energy Demands During Cold Weather Operations at Naval Health Research Center conference, Current Challenges in Cold Weather Research, San Diego, CA, April 1992.

27. Eldon W. Askew, COL, MS. Military Nutrition mission and research. Briefed to Colonel J.D. Sankey, OBE, Assistant Military Attaché and Deputy Commander, British Army Staff, UK. Natick, MA, June 1992.

28. Eldon W. Askew, COL, MS. Combat Rations and Nutritional Issues. Briefed to LTC (Dr.) Low Wye Mun, Senior Medical Officer, Army, Singapore Ministry of Defense, Natick, MA, July 1992.

29. Eldon W. Askew, COL, MS. Military nutrition research briefing. Briefed to Brigadier Ian B.R. Fowler, Military Attaché and Commander, British Army Staff, Natick, MA, October 1992.

30. Eldon W. Askew, COL, MS. Status of Past and Current Military Research on Nutritional Enhancement of Soldier Performance. Briefed to Committee on Military Nutrition Research workshop to evaluate potential performance enhancing food components for operational rations, Washington, DC, November 1992.

31. Carol J. Baker-Fulco. Performance Nutrition Intervention Project. Briefed to BG Norman Lezy (Director, U.S. Air Force Morale, Welfare, and Recreation Services), Natick, MA, March 1992.

32. Barry Fairbrother, MAJ, British Special Projects Officer at USARIEM. Overview briefing on military nutrition research to Col Peter F. Lutter (British Medical Liaison Officer, Office of The Surgeon General), Natick, MA, August 1992.

33. Nancy King, LTC, SP. Military Nutrition research overview. Briefed to BG Norman Lezy (Director, U.S. Air Force

Morale, Welfare, and Recreation Services), Natick, MA, March 1992.

34. Nancy King, LTC, SP. USARIEM overview with emphasis on Military Nutrition Division. Briefed to Marriott Hotel management services staff visiting U.S. Army Natick Research, Development and Engineering Center, Natick, MA, April 1992.

35. Nancy King, LTC, SP. Update on Nutrition Research at USARIEM at regional conference for chiefs and NCOICs of nutrition care, Fort Meade, MD, July 1992.

36. Nancy King, LTC, SP. Military Nutrition research overview. Briefed to Wing Commander S. Edgar (Head of Tri-Service Research and Development for Food for UK Armed Forces), Natick, MA, October 1992.

37. Robert J. Moore, CPT, MS. Changes in Soldier Nutritional Status, Physical Performance, and Immune Function During the Ranger Training Course ("Ranger I"). Briefed to COL Maher, Commander, Ranger Training Brigade, Fort Bragg, NC, January 1992.

38. Robert J. Moore, CPT, MS. Principal Investigator briefing on "Ranger I" results to Committee on Military Nutrition Research, NAS, Washington DC, February 1992.

39. Robert J. Moore, CPT, MS. Soldier's Concerns: Nutritional Content of Operational Rations-ODS Experiences. Briefed to Nutrition Labeling for Operational Rations meeting, Washington, DC, June 1992.

40. Cecilia D. Thomas, MAJ, SP. Current and projected research studies of Military Nutrition Division. Briefed to Army Nutrition Planning Meeting, Natick, MA, March 1992.

41. Cecilia D. Thomas, MAJ, SP. Nutrition and Operational Rations. Briefed to BG Richard E. Beale, Jr., (Commander, Defense Personnel Support Center), Natick, MA, March 1992.

42. Cecilia D. Thomas, MAJ, SP. Mission and current research of Military Nutrition Division. Briefed to MAJ Joan Lyons

(staff dietitian for Deployable Medical Systems Facility Planning), Natick, MA, August 1992.

SIGNIFICANT TDY:

Eldon W. Askew, COL, MS. To plan for Committee on Military Nutrition Research meeting, Washington DC, May 1992.

Eldon W. Askew, COL, MS. Grant officer review of proposed work to be conducted under new grant, Louisiana State University, Baton Rouge, LA, May 1992.

Eldon W. Askew, COL, MS, Ronald L. Shippee, MAJ, MS, Tanya E. Jones, and Catherine Gabarée. Site visit to coordinate Cooperative Research and Development Agreement and to present Metabolic Ward Study parameters to Pennington Biochemical Research Laboratory staff, Pennington Biomedical Research Center, Baton Rouge, LA, December 1992.

Carol J. Baker-Fulco. Briefing of Altitude study participants on multifrequency bio-impedance measurements, Pikes Peak, CO, August 1992.

Barry Fairbrother, MAJ, British Special Projects Officer. Invited judge at the 17th annual U.S. Army culinary competition, Fort Lee, VA, April 1992.

Barry Fairbrother, MAJ, British Special Projects Officer. Coordination visit for the "Ranger II" study, Fort Benning, GA, May 1992.

Tanya E. Jones. Field evaluation of hydrational status and food intake of marines performing work at moderate altitude, Bridgeport, CA, January 1992.

Tanya E. Jones. Army Nutrition Planning Committee. Washington, DC, October 1992.

Tanya E. Jones. American College of Sports Medicine New England Regional Chapter meeting, November 1992.

Nancy King, LTC, SP. Altitude study participant with emphasis on caffeine data collection, Pikes Peak, CO, August 1992.

Nancy King, LTC, SP; C. Clifton Murphy, LTC, SP; Ronald L. Shippee, MAJ, MS; Carol J. Baker-Fulco. Committee on Military Nutrition workshop participants, Washington, DC, November 1992.

Robert J. Moore, CPT, MS, and Cecilia D. Thomas, MAJ, SP. Discuss planning and implementing of nutrition labeling for operation rations, Falls Church, VA, June 1992.

Ronald L. Shippee, MAJ, MS. "Ranger II" coordination visits, Fort Rucker, AL, and Fort Benning, GA, May 1992.

Ronald L. Shippee, MAJ, MS. Conference on Trace Element Metabolism. Washington, DC, June 1992.

Ronald L. Shippee, MAJ, MS. Site visits to coordinate "Ranger II" study: Columbus, GA, Dahlonega, GA, Fort Walton Beach, FL, Anniston, AL, El Paso, TX, and San Antonio, TX, July 1992.

Ronald L. Shippee, MAJ, MS. To perform physiological testing and blood draw to determine baseline values for phase I of "Ranger II" study, Fort Benning, GA, August 1992.

Ronald L. Shippee, MAJ, MS, and study team. "Ranger II" follow-up study. Columbus, GA, Dahlonega, GA, Fort Walton Beach, FL, El Paso, TX; August, September, October 1992.

Cecilia D. Thomas, MAJ, SP. Site visit to coordinate menu modification for dining facility study, Fort Polk, LA, May 1992.

Cecilia D. Thomas, MAJ, SP. Attend Army Nutrition Planning Committee, Falls Church, VA, June 1992.

Cecilia D. Thomas, MAJ, SP. Coordinate meeting on menu modification project, Fort Lee, VA, July 1992.

SIGNIFICANT VISITORS:

R. Scott Van Zant, Ph.D., USDA. Seminar on Effects of Dietary Carbohydrate and Fat on Exercise Performance, January 1992.

Per Kristian Opstad, Ph.D., Norwegian Defense Research Establishment, presented a seminar, Nutrition, Sleep Deprivation, and Performance, February 1992.

Robert Reynolds, Ph.D., Department of Nutrition and Medical Dietetics, University of Illinois at Chicago, presented two seminars: Energy Metabolism During an Ascent of Mount Everest, and Physiological Aspects of High Altitude Exposure During an Ascent of Mount Everest, March 1992.

John M. Kinney, M.D., Rockefeller University. Seminar, Energy Metabolism: Substrate Balance vs. Thermal Balance, April 1992.

T. Peter Stein, Ph.D., Professor of Surgery, University of Medicine and Dentistry of New Jersey. Seminar, Structured Fats: Are They Different?, September 1992.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

COL Eldon W. Askew, Ph.D., Division Chief. U.S. representative to the Commonwealth Defence Science Research Organization, Food Science and Preventive Medicine Groups; DOD representative to the Interagency Committee for Federally Funded Human Nutrition Research; Army Liaison to NAS Food and Nutrition Board Committee on Military Nutrition Research; member, Nutrition Advisory Panel, United States Olympic Committee; invited journal reviewer of Journal of Applied Physiology, Journal of Nutrition, American Journal of Clinical Nutrition, Physician and Sportsmedicine, and Journal of the American Dietetic Association.

LTC Nancy King, Ph.D. Invited reviewer of Spanish language manuscripts for The American Dietetic Association.

MILITARY PERFORMANCE & NEUROSCIENCE DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

1. Demonstrated that giving tyrosine to rats resulted in a dose-dependent increase in the release of brain norepinephrine and the improvement of performance during cold stress. Tyrosine was administered in doses of 200 and 400 mg/kg immediately prior to exposure to acute environmental stress (a 20-min exposure to a cold water bath and physical restraint). Performance was assessed with the Porsolt swim test immediately following the stress exposure. Animals pretreated with tyrosine were less adversely affected by exposure to stress. Other animals were treated with tyrosine or placebo and exposed to the same environmental conditions prior to having brain neurotransmission assessed. Norepinephrine was measured in the hippocampus using microdialysis, which permits minute-by-minute assessment of changes in brain neurotransmitters. Tyrosine significantly elevated the release of norepinephrine, suggesting that it may have beneficial results due to its effects on brain catecholamines. These results demonstrate that a nutrient can protect animals against the adverse effects of environmental and behavioral stress.

2. Demonstrated that tyrosine augmented the performance-enhancing effects of sympathetico-mimetic drugs during cold stress. Phenylpropanolamine, an over-the-counter sympathetico-mimetic drug, increased the beneficial effect of tyrosine on the coping behavior of rats, as did amphetamine. Immediately following a 20-min exposure to a cold water bath (which lowered body core temperature to 30°C) and physical restraint, performance was assessed with the Porsolt swim test. Animals pretreated with tyrosine in combination with either drug were less adversely affected by exposure to stress. The combination of tyrosine with either drug produced greater beneficial effects than the highest dose of tyrosine tested alone. These results demonstrate that a nutrient in combination with an over-the-counter drug or a commonly prescribed stimulant can protect animals against the adverse effects of environmental and behavioral stress.

3. Demonstrated that tyrosine improved learning and memory in rats during hypobaric hypoxia. Exposure to hypobaric hypoxia produces rapid, severe decrements in a variety of behavioral functions, particularly learning and memory. The Morris water maze was used to evaluate the effects of tyrosine on spatial learning and memory of rats exposed to hypoxia for seven hours. Tyrosine was administered in a 400 mg/kg dose at 1.5 and 5.5 hours after ascent to a simulated altitude of 5950 m (19,500 ft). Hypoxia significantly impaired the performance of placebo-treated control animals, while tyrosine protected against deficits in working memory in the treated group. These results demonstrate that a nutrient can protect animals against the adverse effects of environmental stress.

4. Demonstrated, using _in situ_ hybridization in rats, that acute environmental stress modified the genetic expression of vasopressin and corticotropin-releasing factor. _In situ_ hybridization is a histological technique which measures levels of mRNA produced by specific genes. It can be employed to monitor changes in the expression of genes in specific brain regions which are associated with exposure to stress. Local mRNA expression of two endogenous factors that participate in the regulatory response to stress, hypothalamic vasopressin and corticotropin releasing factor, have been evaluated in this laboratory. The objective of this project is to identify the source of stress-induced changes in the central nervous system and to develop highly specific neuroprotective agents to facilitate performance-enhancing (coping) changes, while inhibiting performance-degrading changes.

5. Developed methods for assessing the electrophysiological, neurochemical, and behavioral effects of endogenous compounds which regulate alertness during stress. The changes in the brain which regulate sleep and alertness during extended environmental and operational stress are not well understood. However, the severity of side effects of many pharmaceutical products is known to be influenced by circadian rhythms of sleep and alertness. Recent advances in the study of sleep and alertness suggest that the neurohormone melatonin may influence activities in widely dispersed cortical and subcortical areas of the brain, which, in combination, modulate alertness. A procedure for simultaneously measuring

the cortical and subcortical electrophysiological and neurochemical effects of neurohormones was developed. This procedure will be used to conduct experiments defining the mechanism of action of the neurohormones which regulate sleep and alertness.

6. Demonstrated the feasibility of using captured speech technology to assess the degradation of affective and cognitive behavior during exercise in hot-dry and hot-humid environments. A data-collection methodology, which captures verbal, rather than written, responses to questionnaires or cognitive tasks was evaluated during a laboratory study of heat stress and exercise. Each questionnaire item was read to subjects by a psychology specialist. Each subject wore a small tube microphone, positioned by his lips; his spoken responses were recorded on a separate channel of an audio tape for subsequent analysis. This assessment approach was compatible with marching on a treadmill in the heat in different uniform configurations, including helmets and chemical protective masks, and permitted the simultaneous collection of physical and intellectual performance data. Even in this stressful situation, subjects remained highly motivated to complete the questionnaires and cognitive tasks. The methodology will be refined in future studies, using computer-driven voice processors to encode verbal responses directly into an automated data base.

7. Designed and constructed a prototype miniature vigilance monitor, which is able to assess performance in real-time and warn the wearer of lapses in alertness. Few devices are currently available to reduce deficits in performance attributable to fatigue, disrupted sleep-rest cycles, or sustained operations. An unobtrusive device to monitor alertness and warn of lapses in attention which could be worn by the soldier might prevent severe performance deficits. A prototype belt-worn device was constructed using custom-designed components to record spontaneous activity and monitor the wearer's responsiveness. Algorithms were developed which use this information to determine when the wearer should be alerted to a probable lapse of attention. Development is continuing to produce a rugged, waterproof, device to be worn on the wrist which could be used to quantify performance

decrements caused by pharmaceutical or materiel countermeasures to a chemical agent threat.

8. Summarized data describing the degree of degradation in unit effectiveness on information-processing tasks as a function of uniform, ambient temperature, and humidity. Leaders need as much information as possible about the impact of the environment and military operations on the health and performance of their soldiers. Very little systematic information exists with regard to the cognitive performance of soldiers working in hot environments while wearing chemical protective clothing. Identical scenarios, tasks, training procedures, and exposure times were used in five studies of the effects of uniform, ambient temperature, relative humidity, and gender on the performance of military tasks. The results were summarized in tabular form to serve as a guideline for estimating the percent of reduction in unit effectiveness on information-processing tasks during extended operations in hot environments, with or without chemical protective clothing.

9. Demonstrated that psychosociological factors significantly influenced casualty rates during simulated sustained chemical defense operations. A series of field tests designed to identify the problems encountered with sustained work in an NBC environment have documented the inability of physiological measures, such as core temperature or heart rate, to reliably account for the variance in the rate at which soldiers become a heat or performance casualty. Several psychosociological factors have been identified which, independent of workload, account for substantial portions of the variance in casualty rates. For example, younger soldiers are more likely to become casualties, as they are less physically fit, or soldiers who are thinking of leaving the Army as a result of concerns about their spouses or families. Perhaps more importantly, it has become increasingly clear that almost all casualties (heat or performance) occur in the first two days of an exercise, regardless of whether those are the most difficult days or whether soldiers who have become a casualty on the first day are allowed to return on subsequent days. Thus, it seems clear that there are predisposing individual factors which influence the soldier's willingness

to continue working in the presence of symptoms of physical and mental stress.

10. Demonstrated the feasibility of using off-the-shelf data visualization software to model the effects of environmental and operational stressors on rifle marksmanship performance. Data visualization software packages for MS/DOS®-compatible, Windows®-compatible, and Macintosh® hardware were tested to determine the ease with which they could (a) fit curves to existing rifle marksmanship data and (b) provide mathematical algorithms describing the curve generation procedure. Although at least one package in each of the categories proved adequate to the task, Windows-compatible software provided the greatest flexibility. Preliminary analysis of the best fitting curves suggests that rifle marksmanship performance is not a simple linear function of environmental parameters.

11. Assessed the impact of a sustained multi-stressor environment on the cognitive performance of Ranger trainees. Ranger trainees are an elite group of highly motivated soldiers who are subjected to severe food and sleep restriction under operational conditions characterized by danger, intense exercise, and harsh environments. Earlier investigations demonstrated that these conditions lead to an energy deficit, loss of body weight and suppression of both endocrine and immune function. The study investigated the impact of a small increase in calories on cognitive, endocrine, and immune function, as well as nutritional status. Preliminary data on cognitive performance indicated that soldiers functioned at 60% efficiency on information-processing tasks following six weeks of Ranger training.

12. Assessed the influence of body composition, physical fitness, and endocrine function on the ability of female soldiers to perform sustained intense cognitive work while wearing chemical protective clothing in a hot, humid environment. Identical scenarios, tasks, training procedures, and exposure times have been used in five previous studies of the effects of uniform, ambient temperature, relative humidity, and gender on the performance of military tasks. Those studies defined the percent of reduction in unit effectiveness induced by heat and MOPP4 and identified an apparent gender difference in the severity of performance

degradation. The current study uses previously validated performance assessment methodology to identify the relationship between performance deficits and individual differences in physiology: phase of the menstrual cycle, sympathetic nervous system arousal, body composition, maximal oxygen uptake, thermoregulatory response, and cardiovascular response are all being measured. The relationship of these variables to the ability to sustain intense cognitive work will be incorporated into mathematical models predicting soldier effectiveness in a CB environment.

13. Demonstrated that sleeping in the chemical protective mask (M40) compromised mask fit, disrupted sleep, and impaired psychomotor performance. Nine male volunteers participated in a study of the consequences of sleeping in the M40 mask. Each subject slept in the laboratory on eight nights and wore the mask on half of those nights. The level of protection afforded by the mask during the night was measured using the Army's mask-fit validation device. Duration and fragmentation of sleep was measured using a wrist-worn activity monitor. Residual effects of sleep loss on next-day performance were measured using a desktop multi-task simulator (SYNWORK) and a choice reaction-time task. Total sleep time decreased and sleep fragmentation increased when wearing the mask. Mask fit was compromised as a function of restlessness and sleep loss. Error rates increased the next day on both the simulation and the choice reaction-time tasks as a function of sleep loss.

14. Developed a statistical index of subjective heat illness and demonstrated its ability to distinguish between nutritional strategies for improving heat acclimatization. A study was conducted to evaluate the influence of dietary salt intake (4-grams salt per day vs. 8-grams salt per day) on soldiers' subjective reports of symptoms of heat illness during heat acclimation. Subjective reports of heat illness were assessed by means of the daily administration of the USARIEM Environmental Symptoms Questionnaire (ESQ). The results indicate that, regardless of diet, the predominant symptoms appearing during heat acclimation are: warmth, sweatiness, weakness, irritability, restlessness and rapid heart beat, with dizziness and disturbed coordination occurring most often only during the first two days of heat acclimation. However, subjects on the 8-gram salt diet

experienced fewer symptoms (the predominant symptom was tiredness) than did subjects on the 4-gram diet (predominant symptoms included irritability, weakness, constipation, rapid heart beat, restlessness, and thirst). The formulation and analysis of an ESQ-derived, overall index of subjective heat illness (SHI) showed (a) that each group independently responded to the heat such that by the fourth day of heat exposure, subjective heat illness had reached a level which did not differ from any of the succeeding days, i.e., the soldiers had acclimated, and (b) that the two diet groups differed only during the first two days of heat exposure, with soldiers on the 4-gram salt diet reporting more subjective heat illness.

15. Demonstrated that the affective and cognitive behavior of soldiers eating MREs for 30 days was not significantly different from that of soldiers eating the standard field-feeding regimen. Questionnaires which asked soldiers to rate the incidence and severity of symptoms of illness, positive mood, negative mood, intellectual functioning, and psychomotor functioning were administered nine times during a 30-day field exercise, including before and after periods of intense exercise. Soldiers eating only MREs during this 30-day field exercise showed the typical profile of changes in health, mood, and psychological performance, which was not significantly different from that of soldiers eating the standard field-feeding regimen of two hot meals and one MRE meal each day. These data clearly demonstrated that soldiers subsisting on MREs adapted well to the rigors of field training; did not perceive their performance to be impaired, and did not experience any negative changes in health or mood.

16. Demonstrated that Marines using mefloquine (a prophylaxis against chloroquine-resistant malaria) were more likely to report symptoms of depression and sleep disturbance than those using chloroquine. Through the administration and analysis of the USARIEM Environmental Symptom Questionnaire (ESQ) and the Profile of Mood States (POMS), USARIEM personnel assessed the symptomatology and psychological moods of U.S. Marine Corps research volunteers participating in a study of their tolerance to mefloquine prophylactic regimens. Marines (n=359) who volunteered for this 12-week study were randomly assigned to one of three-drug conditions: weekly mefloquine

(250 mg per week), loading-dose mefloquine (750 mg mefloquine the first week, followed by weekly doses of 250 mg), and chloroquine (300 mg per week). All Marines were administered the ESQ and the POMS prior to each drug administration. Analysis of the POMS indicated that, compared to other drug groups: (a) the mefloquine loading-dose group reported more intense feelings of depression at the end of week one, and (b) the weekly mefloquine group reported more intense feelings of depression at week six. Although these differences were statistically significant, all means were within the normal range. Analysis of the ESQ indicated that there was a trend for proportionately more reports of unusual dream activity and sleep disturbance in the mefloquine groups.

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PRESENTATIONS:

23. Lieberman, H.R. Food constituents that enhance performance, Keystone Symposium on Nutrition and Central Nervous System Function, Lake Tahoe, CA, February, 1992.

24. Lieberman, H.R., B.J. Fine, J.L. Kobrick, and J.D. Gabrieli. Effects of caffeine on mental performance and mood: Implications for aircrew members. NATO AGARD Symposium, Oslo, Norway, October, 1992.

25. Lieberman, H.R. Pharmacological and nutritional strategies to sustain performance. DoD Human Factors Engineering Technical Group, Huntsville, AL, November, 1992.

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KEY BRIEFINGS:

31. Richard F. Johnson, Ph.D. Impact of atropine, 2-PAM, and chemical protective clothing on military performance. Briefing for LTC Meyerovitch, Israeli Defense Force. USARIEM, March, 1992.

32. Richard F. Johnson, Ph.D. Military performance and neuroscience: Overview of programs and findings. Briefing for USAMRDC Fellows. USARIEM, September, 1992.

33. Mary Z. Mays, Ph.D., MAJ, MS. Military performance and neuroscience: Research programs. Briefing for LTC Meyerovitch, Israeli Defense Force. USARIEM, March, 1992.

34. Mary Z. Mays, Ph.D., MAJ, MS. Effect of deployment, environment, and operations on psychological performance of soldiers. Briefing for "Current Concepts in Environmental Medicine" Course. USARIEM, May, 1992.

SIGNIFICANT TDY:

Richard F. Johnson, Ph.D. To consult with collaborators on data analysis strategies, Walter Reed Army Institute of Research, February, 1992, May, 1992, June, 1992.

Richard F. Johnson, Ph.D. and Donna J. Merullo. To collect data for a study of load-bearing exercise while wearing a double-pack, Aberdeen Proving Ground, MD, November, 1992.

Harris R. Lieberman, Ph.D. To participate in Research Program Reviews at Pennington Biomedical Research Center, Baton Rouge, LA, January, 1992, June, 1992, October, 1992.

Mary Z. Mays, Ph.D., MAJ, MS. To complete an internship in the Office of the Secretary of the Army for Research, Development and Acquisition, Washington, DC, November, 1991 - March, 1992.

Mary Z. Mays, Ph.D., MAJ, MS and Louis E. Banderet, Ph.D. To attend a P^2NBC^2 Psychology Consultants Planning Meeting, Fort Detrick, MD, February, 1992.

Mary Z. Mays, Ph.D., MAJ, MS. To attend meetings of the P^2NBC^2 Technical and Scientific Advisory Group, Fort McClellan, AL, April, 1992, July, 1992.

Mary Z. Mays, Ph.D., MAJ, MS. To collect data for Ranger II study: Fort Benning, GA; Fort McGregor, TX; Camp Merrill, GA; Camp Rudder, FL., August - October, 1992.

SIGNIFICANT VISITORS:

Dr. Aharon Levy, Pharmacology Department, Israel Institute of Biological Research, October, 1992.

Dr. Oleg Medvedev, Professor and Chief, Laboratory for Experimental Pharmacology, Cardiology Research Centre, Moscow, July, 1992.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Mays, Mary Z., MAJ, Ph.D., MS, Division Chief. Member, Technical and Scientific Advisory Group, P^2NBC^2.

Banderet, Louis E., Ph.D., Research Psychologist. Senior Lecturer in Psychology, Northeastern University, Boston, MA. Reviewer, Aviation, Space and Environmental Medicine; Field Manuals, U.S. Army Medical Center and School and U.S. Army Chemical Center and School.

Fine, Bernard J., Ph.D., Research Psychologist. Reviewer, Psychological Reports; Perceptual and Motor Skills.

Johnson, Richard F., Ph.D., Research Psychologist. Member, USARIEM Quality Assurance Committee. Senior Lecturer in Psychology, Northeastern University, Boston, MA. President, Natick Chapter of Sigma Xi, The Scientific Research Society. Reviewer, Psychosomatic Medicine; Journal of Aging and Health; Human Factors.

Kobrick, John L., Ph.D., Research Psychologist. Senior Lecturer in Psychology, Northeastern University, Boston, MA. Reviewer, Aviation, Space and Environmental Medicine; Military Psychology, Perceptual and Motor Skills.

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Lieberman, Harris R., Ph.D., Research Psychologist. Visiting Scientist, Department of Brain and Cognitive Sciences, Massachusetts Institute of Technology, Member, USARIEM Scientific Review Committee. Reviewer, Physiology and Behavior, Brain Research Bulletin, Psychopharmacology, Journal of Neural Transmission, Military Psychology.

OCCUPATIONAL MEDICINE DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

1. Historically, blisters have plagued the feet of infantry forces and reduced the combat effectiveness of military units. The ability of a prototype sock system to reduce blister incidence was studied in Marine recruits at Marine Corps Recruit Depot, Parris Island, SC, from May to August, 1992. Subjects were separated into three groups. The first group wore the standard issue sock consisting of a wool-cotton-nylon-spandex yarn (group SS, N=160). The second group wore the standard sock with an additional thin inner sock made of polyester (group SL, N=106). The third group wore the same thin inner sock under a thick, dense, prototype outer sock made of a wool-polypropylene combination yarn (group PL, N=91). Recruits in the PL group suffered significantly fewer blisters compared to recruits in either the SS group (40% vs 69%, $p<0.001$) or the SL group (40% vs 77%, $p<0.001$). The rate of blister occurrence was also less in the PL group (11 blisters/100 recruits/week) compared to the SS group (28 blisters/100 recruits/week) or the SL group (26 blisters/100 recruits/week). Blisters, serious enough to require a sick call visit, occurred with greater frequency in the SS group compared to both the PL group (24.4% vs 11.0%, $p=0.02$) and the SL group (24.4% vs 9.4%, $p<0.01$); there was no difference between the SL and PL groups. Blister reduction was most apparent in the early weeks of recruit training. The prototype sock system reduced the overall incidence and severity of blisters in Marine recruit training.

2. Foot blisters are one of the most common injuries associated with military road marches. Blisters are usually a relatively benign injury from which most soldiers recover quickly, but they can become acutely disabling and prohibit further weight bearing activity. They may also predispose the soldier to local or systemic infection which can result in significant time-loss. Therefore, developing preventive strategies to reduce the incidence and severity of blisters is an important aspect of our injury research program. We recently completed an experimental study that examined whether antiperspirants applied to the feet reduced the incidence of foot blisters in 24 soldiers marching with a load of (46 lbs) on a treadmill for 12 miles in a warm environment. Other outcome measures included skin bacterial colony counts, foot temperatures and incidence of contact dermatitis. Preliminary results indicate that antiperspirants reduce foot sweat rate by 26% (MANOVA,p=.07) and skin bacterial colony counts by 27% (t-test, p=.03 MANOVA pending) with no incidence of contact dermatitis. Also, while not statistically significant, the antiperspirants reduced blister incidence during the treadmill march. Thus, antiperspirants may be a preventive strategy for reducing foot moisture, associated blisters and other complications such as infection. These findings need to be confirmed in a larger sample.

3. The metabolic cost of locomotion (E_l) is proportional to the ratio of body mass (m_b) to the amount of time the foot is in contact with the ground (t_c) (Kram, Nature 346: 265-267, 1990). Using this relationship, we developed a portable electronic foot contact monitor and used this monitor to derive and validate an equation to estimate E_l from t_c and m_b. Twelve males were tested during horizontal treadmill walking (3.2, 4.8, and 6.4 km/h) and running (8.8, 10.5 and 12.1 km/h). Energy cost (E_l) was measured by indirect calorimetry with resting energy expenditure subtracted out. To derive the equation, six subjects were randomly selected and linear regression analysis performed. The resulting equation was: predicted $E_l = 3.77(m_b/t_c) - 162.3$ (r=0.99, SEE=93W). This equation was cross-validated in the remaining six subjects and the estimated E_l was found to be highly correlated with the measured E_l (r=0.99). Individual error between estimated and measured E_l was (M$\pm$SD) -1$\pm$13% (range -21 to 29%). The energy

cost of human locomotion can be accurately estimated with a simple foot contact monitor and body mass.

4. Eccentric muscle actions have been shown to be the type of exercise that causes the greatest muscle damage. To develop markers of muscle tissue damage we performed a 28-day laboratory study examining changes in knee extension strength and plasma creatine kinase concentration (CK) following four bouts of eccentric leg cycling (each bout separated by one week). Strength and CK were measured daily. Following the first exercise bout, knee extension strength declined 27% ($p<0.01$); it returned to baseline values on the fourth post-exercise day. Following exercise bouts two through four, strength immediately post-exercise was significantly lower than baseline ($p<0.05$) but quickly returned to baseline values. CK was elevated one day after the first exercise bout and reached its maximal elevation eight days after the first exercise bout ($p=0.02$). CK declined after reaching its peak and was not affected by subsequent exercise bouts. We extended this study to the field by examining changes in strength and CK following two maximal effort 20-km road marches performed by eight Special Operations Soldiers. In consonance with laboratory findings, leg strength was reduced following both marches ($p<0.05$). CK was elevated after the first march in all subjects and in subjects that carried a heavier load on the second march ($p=0.001$). These data indicate that both strength and CK are potentially useful markers of muscle tissue damage that may be easily employed in field studies.

5. The metabolic requirements of eccentric exercise were studied in seven healthy male soldiers in order to better understand adaptations to exercise that result in muscle tissue damage. Subjects exercised once per week for four weeks at 220 watts on a specially constructed, eccentric leg-cycling ergometer (total exercise time = 20 min). Oxygen uptake (VO_2), heart rate (HR), respiratory exchange ratio (RER), rating of perceived exertion (RPE), and a blood sample were obtained after every five minutes of exercise. Ratings of muscle soreness (RMS) were obtained each morning. Subjects were confined to a metabolic ward two days before the first exercise bout and remained in the ward through the third exercise bout. RMS were elevated after the first exercise

bout ($p<0.01$) but only minimally after subsequent exercise bouts ($p<0.1$). From exercise bouts one to four there were reductions in VO_2 ($p<.001$), HR ($p<.001$), RER ($p<0.05$), RPE ($p<0.001$) and lactate ($p<.001$). Within bouts (between 5 and 20 min), VO_2, HR, and lactate increased a mean of 26% ($p<.001$), 19% ($p<.001$), and 38% ($p=.012$), respectively. The pattern of change was not significantly different (interaction $p>.05$) for these measures from bout to bout. Subjects demonstrated significant metabolic adaptation to eccentric leg cycling, as demonstrated by improvements in efficiency, lower HR, reduced lactate accumulation and reduced RER. Further adaptation may take place with additional exercise bouts. These results have important implications for military training involving tasks with a high eccentric component, such as running or road marching.

6. Muscle cross sectional area (CSA) may be related to physical training injuries since soldiers with less muscle area may have inadequate strength for particular types of activity and be more susceptible to muscle strains and joint sprains. The relationship between muscle area and dynamic strength was studied in nine males (age=21.0 yrs) and nine females (age=25.2 yrs). CSA of the right knee extensor muscles was determined by magnetic resonance imaging (MRI) and computerized planimetry on two occasions (femur and subcutaneous fat areas were partitioned out). Test-retest reliability was 0.96 ($p<0.001$). Isokinetic strength of the knee extensors (KE) was measured on a Cybex II ergometer at 60°/sec and 240°/sec as peak torque (PT) and torque at 150° of knee extension (T150). Correlations between strength and CSA were:

	60°/sec		240°/sec	
	PT	T150	PT	T150
Males	0.63	0.63	0.56	0.54
Females	0.87	0.74	0.78	0.77

All correlations were statistically significant ($p<0.05$). Results indicate a moderate relationship between dynamic strength and MRI assessed CSA of a specific muscle group.

7. Numerous reports indicate that ankle injuries in military and civilian populations account for about 40% of parachute jump-related injuries. Studies in athletes have shown that

various methods of bracing the ankle are effective in reducing the frequency and severity of ankle sprains. For these reasons, a prospective, randomized trial of an outside-the-boot ankle brace was conducted to determine if bracing could reduce the incidence of jump-related ankle sprains. Volunteers were sought from four classes at the U.S. Army Airborne School at Ft. Benning, GA. Of 1414 students briefed, 777 volunteered; 389 were assigned to wear braces, and 388 to serve as control subjects. Each volunteer made five static-line parachute jumps. The total number of jumps was approximately 3800. The incidence of ankle sprains was 1.8% in non-brace wearers, and 0.26% in brace wearers(Risk ratio= 6.9:1, p=0.03). The brace did not appear to increase the number of other injuries to the jumpers. Overall, 5.4% of the non-brace group, and 4.6% of the brace group experienced at least one injury when minor contusions are included. The risk ratio for all injuries was 1.2:1 (non-brace to brace groups),(p=0.61, not significant). These results indicate that the incidence of ankle sprains can be significantly reduced by use of an ankle brace without increasing the risk of other injuries.

8. Previous studies report a wide range of injury rates for military parachuting which appear to be greatly influenced by injury definition and reporting methods. Few prospective examinations of injuries and risk factors have been conducted. The purpose of this pilot study was to determine baseline injury rates for basic Airborne Training and to identify problems associated with injury reporting methods in the Army. One Airborne school class of 540 individuals was invited to participate in this survey-based study. Approximately 400 soldiers completed the study. Of the 70 injuries reported, 39% were contusions , 30% sprains, 7% head injuries, 4% fractures, 4% strains, 4% riser burns, and 11% other injuries. Overall injury rates per jump were approximately 2.9% when the broadest definition of injury was employed and 1.8% when minor injuries such as contusions and riser burns were excluded. Given the number of recorded parachute injuries, and the number of annual parachute deployments, either injury rate suggests that injuries have been significantly under reported in the past. In the current study, at least one fracture and three head injuries occurred that could not be picked up by the present DA Form 385 reporting system due to injury

definitions. This finding may indicate the need for an improved injury-surveillance system.

9. Previous studies have demonstrated the severity of injuries related to military parachuting, but none have examined the patterns, types, and causes of injuries in women compared to men. Serious, non-combat, Army injuries are reported to the U.S. Army Safety Center (USASC), Ft. Rucker, AL on a DA Form 385. We searched the USASC database for parachuting injuries among men and women from CY80 to CY90. Over this 10 year period 4726 men and 116 women were reported to USASC for jump-related injuries. The distribution(%) of injuries by anatomical location for men compared to women varied significantly. For men, 56.4% of injuries affected the lower extremities versus 71.6% for women. The percent of total injuries to other locations for men compared to women were: back 14.7% vs. 8.6%, upper extremities 9.9% vs. 2.6%, and head 8.4% vs. 7.8%. Fractures represented 58.1% of injuries in men, vs. 80.9% of injuries in women, sprains 14.8% vs. 3.6%. The reported cause of injury also appeared to vary by gender. An improper parachute-landing fall was implicated in 58.6% of injuries for men vs. 81.8% for women, interference from another jumper 8.6% vs. 2.7%, ground obstacle 8.6% vs. 1.4%, and injury at aircraft exit 5.4% vs. 1.4%. Further study is needed to determine the significance of these findings.

10. Injuries are known to be a leading cause of mortality and morbidity in Army populations. To determine the incidence and causes of injuries resulting in hospitalization for active duty Army soldiers, the Individual Patient Data System at Ft Sam Houston, TX, was queried. Injuries as a group were found to be the leading cause of hospitalization, resulting in 20,762 soldiers receiving hospital care in CY 1989. Injuries accounted for 18.1% of all hospitalizations - twice as many as the second leading cause, infectious diseases. The incidence of hospitalization for injuries was 27.2 per 1000 man-years. Vigorous training and operational activities (marching, drilling, PT, twisting, turning, lifting and pulling) and sports as a group accounted for 24.5% (5,117) of all injuries resulting in hospitalization. These data indicate that activity-related injuries are not only a frequent cause of

injury in Army populations but also a cause of serious morbidity and lost-duty time.

11. In previous studies of basic trainees and light infantry soldiers we found cigarette smoking to be a risk factor for musculoskeletal injuries. We recently replicated this finding in 194 senior military officers (LTC and COL) in the 1991-92 resident class at the Army War College (AWC). Officers who were smokers at the beginning of the 10-month AWC program were 2.0 times more likely than non-smokers to suffer musculoskeletal injuries during the academic year (chi-square p=0.06). There are many potential reasons why cigarette smokers have an increased likelihood of injuries. Carbon monoxide in cigarette smoke decreases blood and tissue oxygenation. Nicotine can cause an over-stimulation of the sympathetic nervous system and increase the potential for muscle spasms. Cigarette smokers may be more likely to be "risk takers" thus increasing their potential for injury. On the other hand, it is also possible that the association between injuries and smoking may be mediated by other factors such as alcohol consumption, physical activity, age, physical fitness or body composition. The influence of these potential confounding factors will be further explored in a multivariate logistic regression model since the necessary data is available in this population. These data suggest that smoking not only affects long term health risks but also short term injury risk, which could have an impact on war fighting capability.

12. We have previously demonstrated that cigarette smoking is associated with higher injury rates among Army trainees and soldiers. We have just completed a study that recorded injuries over a one-year period in 396 male infantry soldiers from two units (mean ages 18.9 and 21.2). We recorded overuse and traumatic musculoskeletal complaints by a 100% review of medical records for all soldiers in both units. A smoking history questionnaire was given to all soldiers and aerobic fitness (2-mile-run time) was measured. Each population was divided into non-smokers, light smokers (≤10 cigarettes/day), and heavy smokers (>10 cigarettes/day). Soldiers that were smokers were 2.0 times more likely to suffer lower extremity musculoskeletal injuries during infantry training than non-smokers (p for trend=.004, Ft. Ord and p for trend=.001, Ft.

Drum). However, we did not find an association between smoking and aerobic fitness. These results suggest that smoking is an independent risk factor for injuries but is not associated with decreased aerobic performance in young male infantry soldiers. The finding that smoking affects short term risk of injury may have important implications for combat readiness.

13. Low levels of strength, lack of flexibility and imbalances in strength or flexibility have long been suspected risk factors for activity-related injuries. We reviewed prospective studies reported in literature on this topic by considering five major aspects: 1) definitions of strength and flexibility, 2) types of activity, 3) definitions of injury, 4) injury risk, 5) statistical analysis and 6) sample size. There were few well conducted studies in this area primarily due to inadequate sample size and data analysis. Available information suggested 1) strength imbalances in the legs (one leg stronger than the other) were associated with greater risk of sprains and muscle strains; 2) too much or too little flexibility in the hip/low back region was associated with lower extremity injuries; 3) flexibility imbalances in the hip region (one side more flexible than the other) may be associated with sprains and muscle strains in the lower body. No relationships were found between absolute strength and risk of injury nor was there any direct evidence that correcting strength imbalances will reduce injury incidence. Future research on this topic should consider the influence of past injuries.

14. To investigate road march performance, Special Operations Forces (SOF) soldiers were studied during and after strenuous road marching. Twenty-one soldiers completed six, 20 km road marches as rapidly as possible in each the six experimental conditions. In separate marches, soldiers carried either a standard Army rucksack or a double-pack with loads of 34 kg, 48 kg and 61 kg (two packs and three loads). March time was recorded every 4 km and the soldiers' heart rates were obtained continuously throughout the march. Performance of typical soldering tasks such as rifle marksmanship, grenade throw accuracy, and ability to negotiate an obstacle course were studied after each march. These data have just been collected and analysis is ongoing.

USARIEM
CY92

PUBLICATIONS:

1. Jones, B.H., M.W. Bovee, J.M. Harris and D.N. Cowan. Intrinsic risk factors for exercise-related injuries among male and female Army trainees. American Journal of Sports Medicine, (In Press).

2. Jones, B.H., K.L. Reynolds, P.B. Rock, M.P. Moore. Exercise-related musculoskeletal injuries: risks, prevention and care. Chapter in: American College of Sports Medicine Resource Manual for Guidelines on Exercise Testing and Prescription, 2nd Edition. Lea and Febiger, Philadelphia, (In Press).

3. Jones, B.H., D.N. Cowan, J.P. Tomlinson, J.R. Robinson, D.W. Polly and P.N. Frykman. Epidemiology of injuries associated with physical training among young men in the Army. Medicine and Science in Sports and Exercise, 25:197-203, 1993.

4. Jones, B.H., M.W. Bovee and J.J. Knapik. Associations among body composition, physical fitness and injury in men and women Army trainees. Chapter in: Body Composition and Physical Performance: Applications for the Military Services. National Academy Press, Washington, D.C., pp. 141-173, 1992.

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8. Knapik, J.J., P. Ang, K. Reynolds and B.H. Jones. Physical fitness, age and injury incidence in infantry soldiers. Journal of Occupational Medicine (In Press).

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10. DiBenedetto, M., M. Yoshida, S. Braverman, M. Sharp, B. Jones, and T. Scully. Foot Evaluation by infrared imaging. Archives of Physical Medicine and Rehabilitation, 73:1019, 1992.

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16. Staab J.S., J.J. Knapik and C.D. Thomas. Metabolic adaptations to repeated bouts of eccentric leg cycling exercise. Medicine and Science in Sports and Exercise, 24:S155, 1992.

PRESENTATIONS:

17. Amoroso, P.J. Military Parachuting Injuries; Retrospective and Prospective Analyses. AMEDD Professional Short Course: Current Concepts in Environmental Medicine. USARIEM, Natick, MA, 14 May 1992.

18. Jones, B.H. Training-related musculoskeletal injuries in military populations: Facts and fiction. Lecture to medical students at Uniformed Services University of Health Sciences, Bethesda, MD, 12 March 1992.

19. Jones, B.H. Epidemiology of injuries in military populations. Seminar for Occupational Medicine graduate students at Uniformed Services University of Health Sciences, Bethesda, MD, 12 March 1992.

20. Jones, B.H. Epidemiology of training-related injuries in military populations. Invited lecture to 33rd Navy Occupational Health and Preventive Medicine Workshop, Virginia Beach, VA, 18 March 1992.

21. Jones, B.H. Training injuries in military populations. AMEDD Professional Short Course: Current Concepts in Environmental Medicine. USARIEM, Natick, MA, 14 May 1992.

22. Jones, B.H. Military training-related injuries. Invited lecture to Advance Course Program entitled "Fitness of the Army", Army War College, Carlisle, PA, 19 May 1992.

23. Jones, B.H. Epidemiology of collapse and other casualties of endurance events. Clinical Lecture at annual meeting of the American College of Sports Medicine, Dallas, TX, 29 May 1992.

24. Knapik, J.J. Principles of Physical Training and Their Application to Improve Military Performance. AMEDD Professional Short Course: Current Concepts in Environmental Medicine. USARIEM, Natick, MA, 14 May 1992.

25. Reynolds, K.L. Injuries Associated with Marching with Loads in the Military. AMEDD Professional Short Course:

Current Concepts in Environmental Medicine. USARIEM, Natick, MA, 14 May 1992.

26. Reynolds, K.L. Association of Smoking and Training Injuries in Light Infantry Soldiers. American College of Sports Medicine, Dallas, TX, May 1992.

27. Reynolds, K.L. Facts and Fiction About Physical Training and Related Injuries. Falmouth Hospital Sports Medicine Symposium, Falmouth, MA, August 1992.

KEY BRIEFINGS:

28. Paul J. Amoroso, MAJ, MC. Military parachuting injuries and strategies for prevention. Briefing presented to COL L. White, 507th Parachute Infantry Regiment, Ft Benning GA, September, 1992.

29. Paul J. Amoroso, MAJ, MC. USARIEM parachute soft landing system. Briefing presented to COL Schnakenberg, COL Ryan, Mr. Sal Raineri, Mr. Bernard Corona, at the LEAP conference, USARIEM, July 1992.

30. Paul J. Amoroso, MAJ, MC. Preliminary results of the parachute ankle brace study. Briefing presented to Mr. Chris Kearns, Combat Development, Infantry School, Ft. Benning, GA, October 1992.

31. Bruce H. Jones, M.D., LTC, MC. Injury surveillance and prevention in the tri-services. Department of Defense Safety and Occupational Health Policy Council, Pentagon, Arlington, VA, 15 January 1992.

32. Bruce H. Jones, M.D., LTC, MC. Overview of USARIEM mission and epidemiology of training injuries in military populations. U.S. Army Safety Center staff, Ft. Rucker, AL, 16 June 1992.

33. Bruce H. Jones, M.D., LTC, MC. Briefing on proposal to study prevention of airborne jump-related injuries in units of the 82nd Airborne Division. To BG Peak, Commander, 44th Medical Brigade, and staff, 15 July 1992 and to COL Keravouri,

Chief of Staff, 82nd Airborne Division, and other staff, Ft. Bragg, NC, 16 July 1992.

34. Bruce H. Jones, M.D., LTC, MC. Briefing on training-related injury research to COL Webe., Director of Combat Development, JFK Special Warfare Center, Ft Bragg, NC, 16 July 1992.

35. Bruce H. Jones, M.D., LTC, MC. Briefing on injury epidemiology research by USARIEM to BG Kerr, Commander, U.S. Army Safety Center, Ft. Rucker, AL, 30 July 1992.

36. Joseph Knapik, MAJ, Sc.D. Load march performance of special operations soldiers carrying various loads and load distributions. Special Operations Forces Combat Developments, Fort Bragg, NC, April, 1992.

37. Joseph Knapik, MAJ, Sc.D. and Katy Reynolds, LTC, M.D. Medical support for study of load march performance of special operations soldiers carrying various loads and load distributions. To medical staff, Kirk Army Hospital, Aberdeen Proving Ground, MD, October, 1992.

38. Joseph Knapik, MAJ, Sc.D. Load march performance of special operations soldiers carrying various loads and load distributions. Briefing presented to Third Special Operations Forces, Fort Bragg, NC, October, 1992.

39. Joseph Knapik, MAJ, Sc.D. and Joyce White, M.S. Tobacco usage and musculoskeletal injuries. Army Physical Fitness Research Institute, Army War College, Carlisle Barracks, PA, December, 1992.

SIGNIFICANT TDY:

Paul J. Amoroso, MAJ, MC, Bruce H Jones, LTC, MC, and staff of twelve. To conduct study "Effect of an outside the boot ankle brace on the incidence of ankle and other injuries associated with military airborne operations." Ft. Benning, GA, September-October 1992.

Paul J. Amoroso, MAJ, MC. To undergo water survival, pressure chamber, and physiologic training program, Naval Air Station, Norfolk, VA, March 1992.

Paul J. Amoroso, MAJ, MC. To attend Winter Wilderness Medicine Conference, Big Sky, Montana, March 1992.

Paul J. Amoroso, MAJ, MC. To attend Air Assault School, Ft Rucker, AL., June 1992.

Bruce H. Jones, LTC, MC. To attend meetings of Centers for Disease Control Advisory Committee on Injury Prevention and Control, Atlanta, GA, February, May, and October 1992.

Bruce H. Jones, LTC, MC. To participate as member of doctoral thesis advisory committee for CDR Dexter Kimsey, U.S.Navy, at University of South Carolina, Department of Epidemiology, Columbia, SC, 22-24 June 1992.

Bruce H. Jones, LTC, MC. To attend course on "Management of Research and Development Organizations", Medical Research and Development Command, Ft Detrick, MD, November, 1992.

Bruce H. Jones, LTC, MC. To chair meeting of the DoD Working Group on Injury Surveillance and Prevention, Pentagon, Arlington, VA, December 1992.

Joseph Knapik, MAJ, Sc.D., Katy Reynolds, LTC, M.D., and Staff of 12. To conduct study "Load March Performance of Special Operations Soldiers Carrying Various Loads and Load Distributions" with Natick Research Engineering and Development Center, Natick MA and Human Research and Engineering Directorate, Aberdeen Proving Ground, MD. Aberdeen Proving Ground, MD, October-November 1992.

Joseph Knapik, MAJ, Sc.D. and John Harris, M.D. To conduct study "Epidemiology of illnesses and Injuries in Senior Military Officers: Effects of Prior Knee Surgery". Army War College, Carlisle Barracks, PA, December, 1992.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Paul J. Amoroso, MAJ, MC, Advanced Cardiac Life Support recertification, Cutler Army Medical Center, Ft Devens, MA. February, 1992.

Bruce H. Jones, M.D., M.P.H., LTC, MC, Division Chief. Chairman, Department of Defense Working Group on Injury Surveillance and Prevention; Department of Defense Representative, Advisory Committee on Injury Prevention and Control, Department of Health and Human Service's Centers for Disease Control. Fellow, American College of Preventive Medicine; Fellow, American College of Sports Medicine; Reviewer, Physician and Sportsmedicine.

Knapik, Joseph J., MAJ, Sc.D. Member, USARIEM Scientific Review Committee; Fellow, American College of Sports Medicine; Member, Science Advisory Committee, Department of Education, Carlisle, PA. Scientific and Technical Manager, Cooperative Research and Development Agreement with Massachusetts Institute of Technology to develop Magnetic Resonance Imaging and Spectroscopy Techniques; Reviewer, Abstracts for 40th Annual Meeting of American College of Sports Medicine, Seattle, WA; Reviewer, Sports Medicine; Medicine and Science in Sports and Exercise; European Journal of Applied Physiology.

OCCUPATIONAL PHYSIOLOGY DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

1. Regional changes in fat-free mass during weight loss are an important consideration in the interpretation of changes in various tests of muscle strength. In the arms and legs, an even more useful estimation of the morphological component of interest, the muscle mass, can be practically achieved using dual-energy X-ray absorptiometry (DEXA), where fat and bone mineral are accounted for. DEXA measurements were obtained on 55 lean young soldiers at the beginning and end of two months of Ranger training. This training imposed heavy exercise and

restricted dietary caloric intake, which resulted in a 12.1 kg weight loss (15.6% of initial body weight). It was found that the relative decline in total mass was greater in the arms (18%) than in the legs (12%). This was consistent with the pattern of weight loss described in the 1950 Minnesota Study of sedentary men on restricted rations. In addition, the extended periods of loaded-walking exercise and the energy deficit appeared to have preserved the leg muscle (2.5% loss) over the arm muscle (12% loss). However, the amount of muscle lost from the arms did not reach a level sufficient to produce a decline in grip strength. In conclusion, regional DEXA measurements can yield new insights into physical performance and body composition relationships.

2. In order to study the effects of extended physical training and caloric deficit on power output, 45 healthy male soldiers were tested before and after a physically demanding 62-day U.S. Army Ranger course to assess 1) fat free mass (FFM) using dual-energy X-ray absorptiometry, 2) dynamic lifting ability (clean lift) using a weight-stack machine, 3) vertical jump, and 4) lean thigh cross-sectional area (CSA). The subjects expended about 4,000 kcal/day but only had food intake of about 2,800 kcal/day. Pre-to-post training changes in FFM and CSA were -6.5% and -13.2%, respectively, while the clean lift decreased 19.8%, vertical jump 16.2%, and peak power from the vertical jump 21.4%. It is concluded that the significant loss in strength and power could not be accounted for solely by the loss in FFM or even thigh CSA, suggesting the importance of neuromuscular and/or metabolic factors.

3. Weight loss is the first line of intervention in overweight hypercholesterolemic patients, but with large weight losses, the serum lipid profile may worsen until a period of stable, reduced-weight maintenance begins. This weight loss-associated serum lipid elevation was confirmed in a group of 50 healthy young male soldiers as they went through a two-month Army Ranger training program involving high energy expenditure (4,000 kcal/day) and low energy intake (2,800 kcal/day). Total cholesterol and both subfractions (HDL and LDL) increased significantly at the end of eight weeks, while the thyroid hormone complex and insulin decreased significantly during this period. Six months after the end of training serum lipids returned to baseline. The rise in the

cholesterol subfractions during substantial and rapid weight loss can be accounted for by typical responses to semi-starvation: hypothyroidism and diabetes-like insulin withdrawal. Increases were seen in growth hormone and cortisol which reflected normal responses to hypoglycemia. Thus, semi-starvation in healthy men can produce a temporary increase in total cholesterol and its subfractions which can be explained by metabolic hormone changes.

4. Teamwork is critical to the successful performance of military tasks that require heavy lifting. However, the effect of increasing team size on cumulative lifting ability has not been well defined. In this study, the relationship was examined between the sum of individual lifts and the team lifting in two- and four-person teams. Thirty-eight soldiers were randomly combined into 26 male, 24 female, and 25 mixed-gender teams. A standard weightlifting bar was used to measure individual lifts from floor to knuckle height. A square of welded tubes with extensions at each corner to hold standard weights was used for team lifts. Team lift, as a percentage of the sum of individual lifts (%S), was 92% for two women, 90% for two men, and 80% for mixed-gender teams. The %S of single-gender two-person teams was greater than the mixed-gender two-person teams, probably because of the large height and strength disparity between genders. In four-person teams, %S was 90% for women, 86% for men, and 84% for two men and two women, with no significant percentage differences between the four-person groups. The female/male strength ratio was 0.60 for one lifter, and did not change with an increase in team size (two-person teams = 0.60; four-person teams = 0.62). The results suggest that a conservative guideline would be to expect a two-person team to lift 1.5 times and a four-person team to lift three times what a single person could lift.

5. Heavy, repetitive lifting represents a major physical task found in many Army MOSs. Frequently, mixed-gender teams are required to perform such tasks in the military environment. In this study, the relationship was examined between the sum of individual lifts and the lifting capacity of three-person, mixed-gender teams. Eleven men and 10 women were randomly combined into 18 teams for each of the following combinations: three men, three women, two men and one woman,

and one man and two women. A standard weight-lifting bar was used to measure individual lifts. A triangle of welded tubes with extensions at each corner to hold standard weights was used for the team lifts (floor to knuckle height). Team lift as a percentage of the sum of individual lifts was 85.0 for three men, 91.0 for three women, 74.4 for two men/one woman, and 82.7 for one man/two women. Based upon these percentages, it is concluded that single-gender teams are more effective than mixed-gender teams and that one man lifting with two women is a more effective combination than two men lifting with one woman.

6. An increased understanding of the biomechanics of load carriage can lead to injury reduction and enhanced performance through physical training, improvements in equipment, technique, or personnel selection. The effects of load on lower body joint torques, muscle activity, and gait kinematics were studied in sixteen male soldiers who carried backpack loads of 6, 20, 33, and 47 kg at a constant speed of 1.3 m/s. During each load carriage condition, soldiers were filmed at 60 Hz from the right side with a 16mm movie camera as they walked across a force platform. EMG's were sampled from the major muscle groups of the back, thigh, and calf. In addition, a triaxial accelerometer monitored pack movement. Major findings were: 1) torques about the ankle, knee, and hip increased with load, with the hip showing the greatest increase, 2) EMG activities of the quadriceps and gastrocnemius muscle groups increased with load; EMG activity of the spinal erectors increased only with the heaviest load, and average EMGs of the trapezius, hamstrings, and tibialis anterior were not affected, 3) significant increases in gait kinematics, e.g., stride frequency, forward trunk lean, and trunk sway, occurred with increasing load. It is concluded that a heavier load places greater burden on the hip and thigh muscles than on those of the calf.

7. Enhanced understanding of the effects of speed on the biomechanics of load carriage could lead to the development of various innovations for lessening medical risk and improving performance. Through the use of high-speed filming and force platform analysis, the effects of walking speeds of 1.1, 1.3, 1.5 m/s on gait kinematics and net torques produced by muscles about lower extremity joints were determined. Sixteen

soldiers walked at each speed with a backpack load of 33 kg. Significant findings were: 1) as the speed increased muscle joint torques increased about the ankle (6%), knee (37%), and hip (51%), 2) with speed, average EMG magnitude increased for quadriceps (41%), hamstrings (75%), tibialis (67%), and gastrocnemius (45%) while spinal erector muscle activity did not increase, 3) with increasing speed, stride length and frequency increase equally, the body dropped lower and faster, and limb ranges of motion increased. The results indicate that the leg muscles are called upon most heavily to increase speed, while the back muscles are little affected. Also, the muscles producing torque about the hip are most involved in increasing speed of load carriage, while those producing torque about the ankle are least involved.

8. Since energy expenditure/metabolic rate is an essential and critical input to heat-strain prediction models, it is important to quantify the energy costs for military occupational tasks as a function of MOPP with a greater degree of certainty. An ongoing study was designed to compare the metabolic cost of military physical tasks performed by soldiers wearing the MOPP 0 and MOPP 4 conditions. In Phase I, 10 men and 10 women performed 14 physical tasks in both MOPP conditions. The results showed significant increases in metabolic cost in MOPP 4 compared to MOPP 0 for tasks which involved whole-body locomotion, such as load carriage or lift and carry. The increases ranged from 5 to 14% for men and 8 to 22% for women. Tasks which were stationary, such as lifting and lowering heavy objects, showed no differences between MOPP conditions. In addition, women exercised at a higher percentage of their maximal capacity in both MOPP 0 and MOPP 4, compared to men. These results suggest that wearing MOPP clothing increases the metabolic demands of tasks that require mobility and that the increase places greater physiological demand on women than men.

PUBLICATIONS:

1. Friedl, K.E. Body composition and military performance: origins of the Army standards. In: Body Composition and Physical Performance. National Academy Press, Washington, D.C., 31-55, 1992.

2. Friedl, K.E., J.P. DeLuca, L.J. Marchitelli, and J.A. Vogel. Reliability of body-fat estimations from a four-compartment model by using density, body water, and bone mineral measurements. American Journal of Clinical Nutrition, 55:764-770, 1992.

3. Friedl, K.E. and R.J. Moore. Ergogenic aids: clenbuterol, Ma Huang, caffeine, L-carnitine, and growth hormone releasers. National Strength and Conditioning Association Journal, 14:35-44, 1992.

4. Friedl, K.E., J.A. Nuovo, T.H. Patience, J.R. Dettori. Factors associated with stress fracture in young Army women-indications for further research. Military Medicine, 157:334-338, 1992.

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9. Harman, E., K. Han, P. Frykman, M. Johnson, F. Russell, and M. Rosenstein. Effects of load carriage speed on muscle torques about the ankle, knee, and hip. In: Proceedings of the 2nd North American Congress on Biomechanics. Chicago, IL, 391-392, 1992.

10. Harman, E.A. and P.N. Frykman. The multiple mini-circuit weight training program. National Strength and Conditioning Association Journal, 14:57-61, 1992.

11. Rice, V.J. A usability assessment of two harnesses for stretcher-carrying. In: Advances in Industrial Ergonomics and Safety IV. S. Kumar (ed.), Taylor and Francis, London, 1269-1274, 1992.

12. Rice, V.J. Ergonomic worksite analysis of an Army dental clinic. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report No. T11-92, 1992.

13. Rice, V.J., M.A. Sharp, T.L. Williamson, and B.C. Nindl. Effects of lift height, direction, and load on the ability to estimate weight. In: Proceedings of the Human Factors Society 36th Annual Meeting, Atlanta, GA, 669-673, 1992.

14. Sharp, M.A., J.J. Knapik, and A.W. Schopper. Energy cost and post-exercise effects of a prolonged, high rate of fire, howitzer simulator training exercise. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report No. T9-92, 1992.

15. Sharp, M.A. and J.A. Vogel. Maximal lifting capacity in military personnel. In: Advances in Industrial Ergonomics and Safety IV. S. Kumar (ed.), Taylor and Francis, London, 1992, 1269-1274.

16. Williamson, T.L. and V.J. Rice. Re-evaluation of the Caldwell regimen: the effect of instruction on handgrip strength in men and women. In: Advances in Industrial Ergonomics and Safety IV. S. Kumar (ed.), Taylor and Francis, London, pp. 675-681, 1992.

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17. Han, K., E. Harman, P. Frykman, M. Johnson, F. Russell, and M. Rosenstein. The effects of various backpack loads on lower body joint torques. Journal of Biomechanics, (In Press), 1992.

18. Han, K., E. Harman, P. Frykman, M. Johnson, F. Russell, and M. Rosenstein. Load carriage: the effects of walking speed on gait timing, kinetics, and muscle activity. Medicine and Science in Sports and Exercise, 24:S129, 1992.

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20. Harman, E., K. Han, P. Frykman, M. Johnson, F. Russell, and M. Rosenstein. The effects on gait timing, kinetics, and muscle activity of various loads carried on the back. Medicine and Science in Sports and Exercise, 24:S129, 1992.

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23. Kramer, T.R., R.J. Moore, K.E. Friedl, and L.E. Martinez-Lopez. Effects of multiple stressors during U.S. Army Ranger training on cell-immune functions. FASEB Journal, 6:A1215, 1992.

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PRESENTATIONS:

25. Friedl, K.E. Ergonomic nutritional aids. National Strength and Conditioning Association Annual Meeting, Philadelphia, PA, June 1992.

26. Friedl, K.E., T. Hendrickson, and D. Wathen. NSCA Primary contact individual accreditation program workshop. National Strength and Conditioning Association Conference, Philadelphia, PA, June 1992.

27. Friedl, K.E., R.J. Moore, E.W. Askew, J.A. Vogel, and L.E. Martinez-Lopez. Lower limits of body fat in active fit men. American Association for the Advancement of Science, Pacific Division Annual Meeting, Santa Barbara, CA, June 1992.

28. Friedl, K.E., J.A. Vogel, L.J. Marchitelli, and S.L. Kubel. Assessment of regional body composition changes by dual-energy x-ray absorptiometry (DEXA). International Symposium on In Vivo Body Composition, Baylor College of Medicine, Houston, TX, November 1992.

29. Nindl, B.C., B.H. Davis, M.T. Mahar, E.A. Harman, and J.F. Patton. Sex differences in anaerobic performance among adolescent athletes. American College of Sports Medicine New England Annual Meeting, Boxborough, MA, November 1992.

30. Sharp, M.A. Matching the physical capacity of women soldiers to Army occupational demands. Human Factors Engineering Technical Group Meeting 29, Systems Integration Subgroup, Huntsville, AL, November 1992.

31. Sharp, M.A. Manual materials handling in the military. Faculty Seminar, Boston University, Boston, MA, October 1992.

<u>KEY BRIEFINGS</u>:

32. Karl E. Friedl, MAJ, Ph.D. Briefing to MG Travis and USAMRDC staff on "Nutritional and Immunological Assessment of Ranger Trainees", Ft. Detrick, MD, 21 February 1992.

33. Karl E. Friedl, MAJ, Ph.D. Briefing of final results from the study "Nutritional and Immunological Assessment of Ranger Trainees" to a national review panel of scientists and senior Army personnel, Washington, D.C., 4-6 February 1992.

34. Karl E. Friedl, MAJ, Ph.D. Briefing to the Ranger Brigade on results of the study "Nutritional and Immunological

Assessment of Ranger Trainees", Columbus, GA, 8-9 January 1992.

SIGNIFICANT TDY:

Everett A. Harman, Ph.D. To serve as judge in the fields of Medicine and Health at the 43rd International Science and Engineering Fair, Nashville, TN, 12-14 May 1992.

John F. Patton, Ph.D. and Valerie J. Rice, MAJ, SP, Ph.D. To attend an OTSG decision meeting on "Return to Duty Criteria" at OTSG, Washington, D.C., 10 February 1992.

Marilyn A. Sharp, M.A. To attend an informational meeting on MEPSCAT at the Pentagon, Washington, D.C., 12 February 1992.

Kathleen A. Westphal, LTC, SP, Ph.D. To serve as invited speaker at the physical and occupational therapy management symposium, San Antonio, TX, 28-30 October 1992.

Valerie J. Rice, MAJ, SP, Ph.D. To serve on special assignment to the U.S. Army Environmental Hygiene Agency to develop DA PAM and intervention program for workstation ergonomics, Aberdeen, MD, 23 August-11 December 1992.

Valerie J. Rice, MAJ, Sp, Ph.D. To attend the Ergonomics II course at the Army Environmental Hygiene Agency, Aberdeen, MD, 3-7 August, 1992.

Valerie J. Rice, MAJ, SP, Ph.D. To serve as invited speaker on the interrelationships of ergonomics and occupational therapy at the U.S. Army Environmental Hygiene Agency ergonomics principles course, Aberdeen, MD, 20-22 May 1992.

Valerie J. Rice, MAJ, SP, Ph.D. To serve as invited speaker on ergonomics and occupational therapy at the Ergonomics/Noise Dosimetry course, Minneapolis, MN, 23-26 June 1992.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Patton, John F., Ph.D., Division Chief. Clinical Instructor, Department of Physical Therapy/Exercise Science, SUNY, Buffalo, NY. Associate Editor, Journal of Strength and

Conditioning Research, National Strength and Conditioning Association Journal; Reviewer, Aviation Space and Environmental Medicine, Military Medicine, Medicine and Science in Sports and Exercise, International Journal of Sports Medicine, and Journal of Applied Physiology.

Friedl, Karl E., MAJ, Ph.D., Research Physiologist. Associate Editor, Journal of Strength and Conditioning Research, National Strength and Conditioning Association Journal. Reviewer, Medicine and Science in Sports and Exercise, Physician and Sportsmedicine, International Journal of Sports Medicine.

Harman, Everett A. Ph.D., Research Physiologist. Adjunct Assistant Professor, Sargent College of Allied Health Professions, Boston University. Vice-President for Basic and Applied Research, and Member, Tests and Measurements, and Research Committees, National Strength and Conditioning Association. Member, Awards Committee, New England Chapter, American College of Sports Medicine. Senior Editor, Journal of Strength and Conditioning Research. Associate Editor, National Strength and Conditioning Association Journal. Reviewer, Medicine and Science in Sports and Exercise.

Rice, Valerie J., MAJ, Ph.D, Occupational Therapist. Member, Army Medical Specialist Corps Research Advisory Group and Mentorship Program. Representative to the American Occupational Therapy Association Roster of Accreditation Evaluators. Reviewer, American Occupational Therapy Association.

Sharp, Marilyn A., MA, Research Health Exercise Scientist. Abstract Reviewer, American College of Sports Medicine.

RESEARCH PROGRAMS AND OPERATIONS DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

1. The experimental sock system developed to decrease blisters, boot lace irritation and tendinitis in marching soldiers was tested in Marine recruits at Parris Island USMC Recruit Depot, SC. The new system significantly reduced the incidence of blisters in these recruits, confirming results found in the previous year with tests performed in SOF and Ranger units.

2. The Animal Care Branch coordinated the development and planning of a post small-animal health clinic for our host facility, the U.S. Army Natick Research, Development and Engineering Center. The planning and recommendation for site location required fully coordinated input from veterinary clinicians, occupational health and safety specialists and facility engineers. The clinic, when established, will provide routine animal health care and immunization for pets of military personnel.

3. USARIEM signed two cooperative Research and Development Agreements in CY92, with the Francis Bitter Magnetic Resonance Imaging (MRI) Laboratory at the Massachusetts Institute of Technology and with Ross Laboratories, a Division of Abbot Laboratories, Inc. The agreement with the Bitter MRI Laboratory provides for the conduct of collaborative research studies with volunteer soldiers into the basic muscle metabolism of heavy physical exercise using MIT's unique MRI technology. The agreement with Ross Laboratories permits USARIEM to evaluate Ross' portable lab instrument for measuring development of fatigue when finger muscles are exercised to exhaustion. It is hypothesized that such muscle fatigue can serve as a predictor of whole-body nutritional status. This may provide military and civilian nutritionists with a portable, rapid means of assessing nutritional status of large populations in remote locations.

USARIEM
CY92

PUBLICATIONS:

1. Darrigrand, A.A., K.L. Reynolds, R. Jackson, M.P. Hamlet, and D.E. Roberts. Efficacy of antiperspirants on feet. Military Medicine 157:256-259, 1992.

2. Darrigrand, A.A. Antiperspirants and feet. (Letter to the Editor). Military Medicine 157:A8, 1992.

PRESENTATIONS:

3. Darrigrand, A.A. The significance of animals used for medical research, U.S. Army Natick Research Development, and Engineering Center, Natick, Massachusetts, 25 February 1992.

4. Darrigrand, A.A. Efficacy of antiperspirants on feet. Faculty and staff, Department of Medicine, Pharmacology, Veterinary Medicine and Laboratory Animal Resources, Ohio State University, Columbus, Ohio, 22 July 1992.

SIGNIFICANT TDY:

Burse, Richard L. To attend combined Small Business Innovation Research and Domestic Technology Transfer Conference, Sterling, VA, 10-12 February 1992.

Darrigrand, Andre A. To attend the 1992 ACCLAM Forum to obtain advanced training of the interrelationships between animal viruses, Lake Tahoe, NV, 3-7 May 1992.

Foster, John M. To consult with the Defence Civilian Institute of Environmental Medicine (DCIEM) of Canada on a future USARIEM environmental chamber construction, features and capabilities. Downsview, Ontario, Canada, 19-21 August 1992.

Foster, John M. To attend the Facility Management Conference, Ft. Detrick, Frederick, MD, 28-29 October 1992.

Hamlet, Murray P. To present a cold briefing and preparation for deployment to Siberia, Defense Nuclear Agency, Las Vegas, NV, 6-8 January 1992.

Hamlet, Murray P. To present a sock/foot injury briefing, at The Infantry School, Ft. Benning, GA, 10 January 1992.

Hamlet, Murray P. To collect data at the Florida Ranger camp, Ft. Walton Beach, FL and conduct a sock briefing at Ft. McClellan, AL, 20-21 January 1992.

Hamlet, Murray P. Guest speaker at the Critical Decisions in Hypothermia, sponsored by Willamette Falls Hospital, Oregon City, OR, 26 February - 1 March 1992.

Hamlet, Murray P. To conduct a sock briefing for the "Council of Colonels" meeting, Ft. Benning, GA, 22-23 March 1992.

Hamlet, Murray P. To coordinate, conduct and obtain data for the sock evaluation with the Marine Corps, Parris Island, SC, 2-3 and 27-29 April, 19-23 May, 19-22 July and 9-13 August 1992.

Hamlet, Murray P. To participate in round table discussion, "Providing medical care in a cold environment." Stockholm, Sweden, 6-10 May, 1992.

Hamlet, Murray P. To attend and participate in the first annual International Activities conference, "International Cooperative R&D in the Post Cold War Era", Ft. Detrick, Frederick, MD, 18-20 August 1992.

Hamlet, Murray P. To present a cold weather seminar for the Cold Regions Research and Engineering Laboratory, Hanover, NH, 11 November 1992.

Hamlet, Murray P. To present an overall review of environmental medicine support, particularly cold weather concerns, and to interview individuals on health and deployment issues when deploying to Antarctica, 20 November - 18 December 1992.

Hubbard, Linda J. To attend meeting at the Institute for Laboratory Animal Management, Olive Branch, MS, 2-7 April 1992.

Modrow, Harold E., MAJ, MS. To attend the USAMRDC Commander's Update, Ft. Detrick, Frederick, MD, 2-3 September 1992.

Modrow, Harold E., MAJ, MS. To attend the Federal Laboratory Consortium meeting, Scottsdale, AZ, 1-5 November 1992.

SIGNIFICANT VISITORS:

Major Gary White, Director, Animal Resources, University of Oklahoma, was present from June 22 to July 3, 1992, in his capacity as the Individual Mobilization Augmentee to USARIEM.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Hamlet, Murray P., D.V.M., Division Chief. Invited presenter, Swedish Military Surgeons Association, Round Table Review of Medical Care in a Cold Environment. Reviewer, Wilderness Medicine Journal.

Burse, Richard L., Sc.D., Research Physiologist. Member, Past-Presidents' Advisory Committee, New England Chapter, Human Factors and Ergonomics Society. Reviewer, American Industrial Hygiene Association Journal and Human Factors and Ergonomics.

Darrigrand, Andre A., D.V.M., Branch Chief. Member, American College of Laboratory Animal Medicine.

Modrow, Harold, E., Ph.D., Branch Chief. Associate Member, Medical Radiobiology Advisory Team, and Adjunct Faculty Member, Defense Nuclear Agency. Adjunct Faculty Member: Naval Aerospace Medical Institute, Pensacola, FL; Naval Undersea Medical Institute, Groton, CT; USAF School of Aerospace Medicine, Brooks AFB, San Antonio, TX.

APPENDIX A

DEPARTMENT OF THE ARMY

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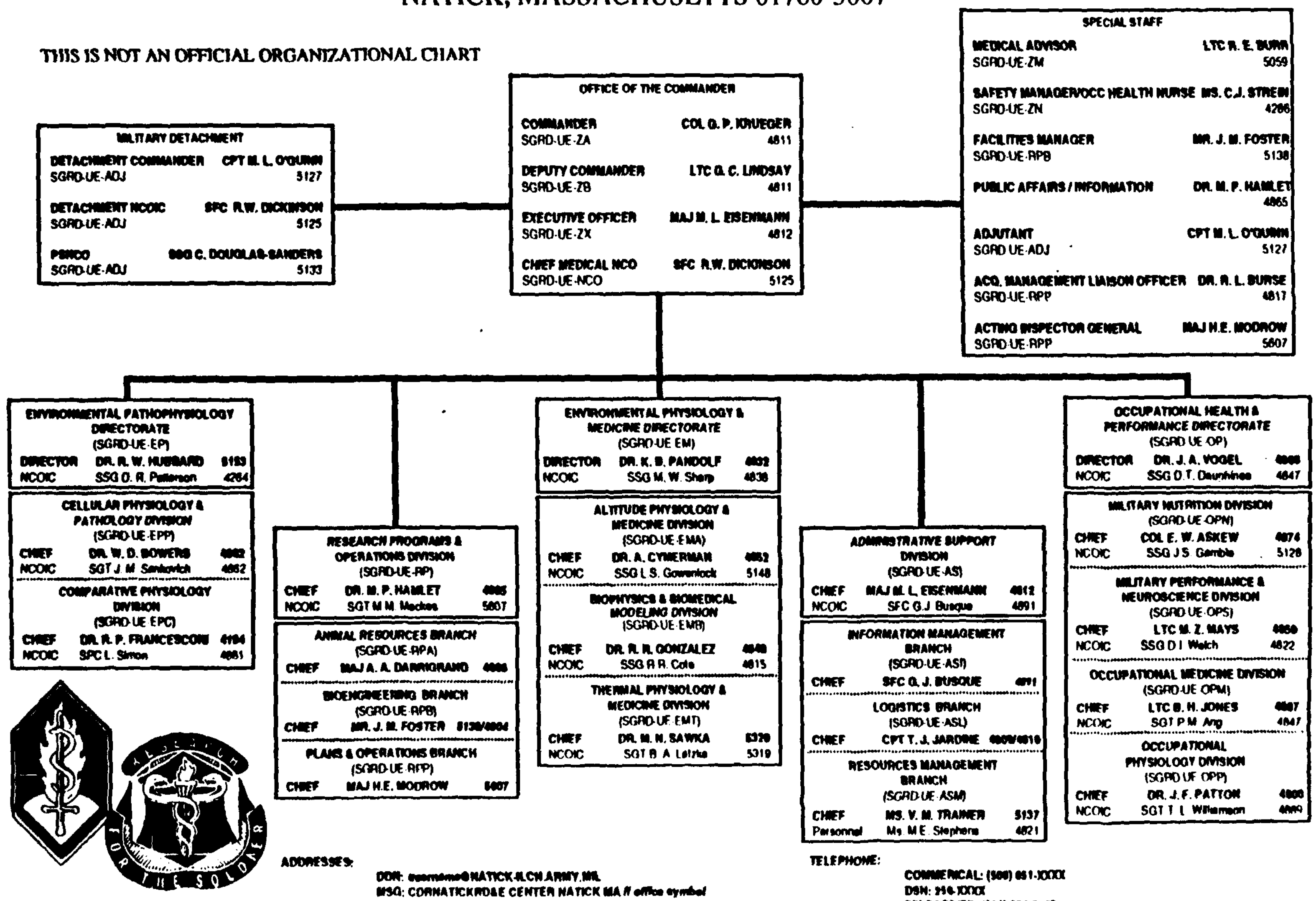

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ATTN: SGPS-PSP
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ATTN: SARD-TM
Pentagon, Washington, DC 20310

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Falls Church, VA 22041-3258

HQDA
Office of the Surgeon General
Assistant Surgeon General
ATTN: DASG-RDZ/Executive Assistant
Room 3E368, The Pentagon
Washington, DC 20310-2300

HQDA
Office of the Surgeon General
ATTN: DASG-MS
5109 Leesburg Pike
Falls Church, VA 22041-3258

Dean
School of Medicine
Uniformed Services University of the Health Sciences
4301 Jones Bridge Road
Bethesda, MD 20814-4799

Department of Military and Emergency Medicine
Uniformed University of Health Sciences
4301 Jones Bridge Road
Bethesda, MD 20814-4799

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ATTN: SGRD-UAX-SI
Fort Rucker, AL 36362-5292

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U.S. Army Medical Research Institute of Chemical Defense
ATTN: SGRD-UVZ
Aberdeen Proving Ground, MD 21010-5425

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U.S. Army Medical Material Development Activity
ATTN: SGRD-UMZ
Fort Detrick
Frederick, MD 21702-5009

Commander
U.S. Army Institute of Surgical Research
ATTN: SGRD-USZ
Fort Sam Houston, TX 78234-5012

Commander
U.S. Army Medical Research Institute of Infectious Diseases
ATTN: SGRD-UIZ-A
Fort Detrick, MD 21702-5011

Director
Walter Reed Army Institute of Research
ATTN: SGRD-UWZ-C (Director for Research Management)
Washington, DC 20307-5100

Commander
U.S. Army Natick Research, Development & Engineering Center
ATTN: SATNC-Z
Natick, MA 01760-5000

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ATTN: SATNC-T
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Natick, MA 01760-5040

Commander
U.S. Army Research Institute for Behavioral Sciences
5001 Eisenhower Avenue
Alexandria, VA 22333-5600

Commander
U.S. Army Training and Doctrine Command
Office of the Surgeon
ATTN: ATMD
Fort Monroe, VA 23651-5000

Commander
U.S. Army Environmental Hygiene Agency
Aberdeen Proving Ground, MD 21010-5422

Director, Biological Sciences Division
Office of Naval Research - Code 141
800 N. Quincy Street
Arlington, VA 22217

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Naval Medical Research & Development Command
NNMC/Bldg 1
Bethesda, MD 20889-5044

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